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ASSESSMENT & MAPPING OF CONTAGIOUS BOVINE PLEUROPNEUMONIA IN KENYA: PAST & PRESENT

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A thesis submitted in partial fulfilment for the degree of Master of Science in Tropical Veterinary Epidemiology at the Freie Universitat Berlin and Addis Ababa University

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DEDICATION

This paper is dedicated to God for His ever present Grace.

To my beloved husband Joseph, to my beloved daughter Grace, to my beloved sons Reuben and Noah for their prayers, love, patience, support and encouragement.

To my parents Patrick and Patricia for raising me up and assuring my education and for their encouragement.

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AGID	Agar gel immunodiffusion test
AHA	Animal health assistant
BEF	Bovine emphemeral fever
BQ	Blackquarter
CBAHW	Community based animal health workers
CBPP	Contagious bovine pleuropneumonia.
CCPP	Contagious caprine pleuropneumonia
cELISA	Competitive enzyme-linked immunosorbent assay
CFT	Complement fixation test
CVFO	Chief Veterinary Field Officer
CVL	Central Veterinary Laboratory
DAAD	Deutscher Akademischer Austauschdienst
Div	Division
DNA	Deoxyribonucleic acid
DSE	Deutsche Stiftung für internationale Entwicklung
ECU	European currency units
EDI	ELISA data interchange
ELISA	Enzyme-linked immunosorbent assay
EMPRES	Emergency prevention system for Transboundary Animal and Plant Pests and Diseases
Endopar.	Endoparasites
FAO	Food and Agriculture Organisation
FMD	Foot and mouth disease
GK	Government of Kenya
GIS	Geographic information system
GPS	Geographic positioning system
GTZ	Gesellschaft für Technische Zusammenarbeit
Haem. Sept.	Haemorrhagic septicaemia
IBAR	Inter- African Bureau of Animal Resources
ISCOM	Immunostimulating complex
JAHA	Junior animal health assistant
JP	Joint Project
KMC	Kenya meat commission
LMD	Livestock marketing division
Loc.	Location
LSD	Lumpy skin disease
*Mmm*LC	*Mycoplasma mycoides mycoides* Large Colony
*Mmm*SC	*Mycoplasma mycoides mycoides* Small Colony
MOA	Ministry of Agriculture
OAU	Organisation of African Unity
OIE	Office International des Epizooties
P. haemolytica	Pasteurella haemolytica
PARC-K	Pan African rinderpest campaign- Kenya

PCR	Polymerase chain reaction
PHA	Passive haemagglutination test
Pneumo.	Pneumonia
R/pest	Rinderpest
SDS - PAGE	Sodium - dodecyl - sulphate - polyacrylamide - gel - electrophoresis
SR	Streptomycin resistant
S	South
TBDs	Tick borne diseases
Tryps	Trypanosomosis
USA	United States of America

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ABSTRACT

A retrospective study was carried out in Kenya with the objective to summarise and map CBPP outbreaks, to relate them to cattle movement patterns, to assess vaccination coverage, and to evaluate factors affecting the reporting of CBPP. Passive data were collected for 1989 to 1998 from district reports, slaughterhouse reports and laboratory reports. Active data were collected by questionnaires in 8 districts: Tana river, where CBPP is believed to be endemic, Mwingi, Makueni, Kajiado, Narok and Thika which are believed to be newly infected, and Kiambu and Nairobi districts which are regarded as CBPP free. 166 farmer, 14 veterinarian, 12 slaughterhouse and 18 paraveterinary personnel questionnaires were administered primarily to determine the factors affecting disease reporting, and to describe the production systems and also additional information on CBPP outbreaks, vaccinations and cattle movement. Map Info Professional and Arc View 3.0a were used to map CBPP vaccinations and its relation to cattle movement patterns. Microsoft Excel 97 and Statgraphics Plus 2.1 were used to store and analyse respectively the data obtained.

In summary, out of 191 CBPP outbreaks 156 (81.7%) were confirmed and 35 (18.3%) were unconfirmed. Of the confirmed outbreaks 46 (29.4%) occurred in areas considered as CBPP free, 78(50.0%) in areas regarded as newly infected and 32 (20.5%) from areas regarded as CBPP endemic. Over the years it became apparent that, while outbreaks were on the decrease, suspected outbreaks showed a slight increase. Outbreaks were more common in the dry season than in the wet season (61.5% vs 38.5%).

When mapping the exact location of the outbreaks it was observed that in the last 10 years CBPP had spread to districts officially still known as clean, i.e the Central Province and Southern districts of Narok and Kajiado and in the Coast Province.

A study of the seasonality of outbreaks indicated that outbreaks were more common in the dry season than in the wet season with 96 (61.5%) in the dry season and 60 (38.5%) in the wet season.

53 (33.9%) of the outbreaks were traced back by the Veterinary Department and all were found to be related to cattle movement such as purchase from CBPP districts (21%), illegal cattle movement for trade or grazing (35%), movement from slaughterhouses (17%), infected neighbour (11%), purchase from other markets (8%), and transboundary migration (8%).

Screening results in the event of an outbreak indicated a range of 0 - 49.7% positive reactors depending on the districts in question while screening of cattle for movement indicated that the proportion of cattle screened from CBPP endemic areas had dropped from 45% in 1989 to 2% in 1997.

District cattle movement patterns were identified, i.e. trade cattle towards Nairobi, Mombasa and the lake region, transhumance movements and cattle rustling across district boundaries where there are ethnic differences, as well as transboundary movement.

45% of cattle destined for slaughter were from endemic districts, 44% from recently infected districts and 11% from clean districts with 17%, 56% and 27% respectively moving to Dagoretti slaughter complex.

The unexplained variation of the number of cattle indicated in cattle movement permits and those actually delivered to Dagoretti complex was seen to increase over the years from < 0.1 to 0.6. Although cattle from unknown origin were rare, days in transit of cattle moving to Dagoretti complex sometimes even reached 40 days and cattle moving without permits reached 12% with 90% of these from Kajiado district.

Vaccination coverage in endemic districts ranged between 20-60% with coverage sometimes rising to over 100%, especially in the border districts of Garissa, Marsabit and the neighbouring Isiolo district. Vaccination coverage in newly infected districts was observed to be less than 25% except in Narok and Kitui.

The unexplained variation between vaccine distributed and that actually used was seen to increase over the years indicating the proportion of vaccine not used upon distribution was increasing.

Monthly vaccination practice followed a distinct pattern beginning at the start of the short rainy season in September and ending at the beginning of the dry season between December to mid-February. However, districts with rainfall throughout the year also vaccinated throughout the year with a major peak during the short rainy season.

Disease ranking by farmers using the questionnaire indicated that CBPP occupies 1^{st} (Thika), 2^{nd} (Mwingi, Makueni, Narok and Kiambu) or 3^{rd} (Tana river) position among the five most important diseases. The veterinarians however ranked it 1^{st} (Tana river) 4^{th} (Mwingi) and 5^{th} (Makueni, Narok and Kajiado) whereas paraveterinary personnel ranked it 4^{th} in Kajiado, Nairobi, Thika and Kiambu and 5^{th} in Mwingi and Makueni.

121 out of 166 (72.9%) farmers interviewed had experienced CBPP in their herds. Mortality rates due to CBPP were indicated to be 30%, 13%, 2%, 0% and 1% in Makueni, Thika, Kajiado, Kiambu and Narok districts with a population at risk of 70000, 800, 14000, 4000 and 1000 in the most recent outbreaks of 1992, 1997, 1998, and 1999 respectively. The economic losses associated with CBPP mortality per farmer per year totalled US$ 3492 in all 8 districts during the last 5 years. Of the farmers who indicated to have had their cattle vaccinated, 60% did so the last year.

Purchased animals, communal watering and grazing, movement of cattle from neighbouring districts, proximity to trade routes, contaminated water, cattle rustling and ticks were cited by the farmers, veterinarians and paraveterinary staff as likely risk factors in CBPP outbreaks investigated.

Rumours were indicated to be present in the various districts by three quarters of the farmers and action taken against rumours by the veterinary personnel included vaccination, investigation and sampling.

CBPP was reported more often to the veterinary office and to the CBAHWs than to the local administration or to traditional leaders. Reasons for not reporting CBPP were quoted as unavailability of and lack of confidence in veterinary personnel, need to contact distant owners, fear of reporting due to the consequences, lack of proper identification of the disease, long distances, lack of transport and impassable roads during bad weather.

However, 140 (84.3%) of the livestock keepers interviewed were able to identify the clinical signs and postmortem lesions of CBPP.

Lack of vaccines and adequate operational funds, breakdown of vehicles and inadequate equipment, lack of cooperation by farmers, banditry and insecurity, illegal vaccinations, uncontrolled migration of cattle, fear of reporting disease and lack of full awareness of the livestock keeper were identified as the major constraints in CBPP control.

In conclusion, CBPP is not only found in the endemic districts of Kenya but rather a new epidemiological zone of newly infected districts, mainly due to cattle movements, has to be defined so that over 70% of the country is now infected. Movement control is not adequate and vaccination falls short of the desirable 100% (200% if done biannually). Abattoir control is not fully geared towards CBPP control. It has therefore been recommended that the suggested rezoning of the country by the Veterinary Department is appropriate, vaccination and movement control should be intensified. The department should seek to harmonise meat inspection with CBPP surveillance by re-educating slaughterhouse personnel. Disease reporting should be improved by educating the farmers more on CBPP and addressing the technical problems of CBPP control which include lack of adequate vaccine, lack of field operational funds and breakdown of vehicles and equipment.

1.0 INTRODUCTION

Livestock production at present contributes about 25% to the total agricultural production value in developing countries (Fitzhugh, 1993).

Livestock raising in Kenya is the sole source of livelihood among the pastoralist communities living in the arid and semiarid regions of which form 70% of the total land with over 50% of the livestock population in Kenya. These regions support 20% of the human population (OIE, 1989).

Among the other uses of livestock are provision of traction power and of plant nutrients in the form of manure. Livestock is also an important asset for investment and insurance for hundreds of millions of rural poor, in situations where banks are often too remote and the banking systems too unreliable for safeguarding any savings a small holder might accumulate. Cattle also provide much needed animal proteins in the form of meat and milk, the demand of which is increasing following population growth, urbanisation and better income among the urban population.

However, livestock productivity in Africa is low due to several constraints which include lack of adequate nutrition due to poor forage quality and scarcity, poor management, incomplete exploitation of the genetic potential of a breed, insufficient extension services and last but not least, rampant animal diseases (Omoregie, 1991)

CBPP is the second most important transboundary livestock disease in Eastern and Southern Africa and a major threat to cattle raising in Africa (FAO, 1997a). In 1993, 23 African countries were reported as having had CBPP outbreaks including Kenya (Masiga and Domenech, 1995). The incidence of the disease is increasing in Africa, mainly in East Africa (Nawathe, 1992; Sylla *et al*., 1995). Clearly, CBPP is a threat to food security.

The epidemiology of CBPP is characterised by transmission through direct contact, a long incubation period and the possibility of early excretion of mycoplasms, up to 20 days before apparition of clinical signs, during the course of the disease and, after recovery, by "lungers" which harbour the pathogens in lung abscesses or sequestra. Spread of the disease is predominantly associated with cattle movement and makes its control difficult in Africa (Masiga and Domenech, 1995).

In Kenya most of the meat consumed is from animals that are raised under the pastoralist production system in the arid and semiarid areas and it is in these areas that the disease is endemic (Masiga and Domenech, 1995). As land allocation in Kenya continues there is less land available per individual herder resulting in an increased tendency to move from CBPP endemic areas to CBPP clean areas in search of any available pasture. This has led to the continuous contact of animals from endemic areas with local "clean" animals leading to outbreaks of the disease in new areas.

Kenya reported 6 (1987), 2 (1988), 15 (1989), 39 (1990), 24 (1991), 11 (1992), 10 (1993), 6 (1994), 6 (1995) and 3 (1996) outbreaks according to the FAO-OIE-WHO Animal Health Year Books and the PARC reports. Most recent reports from the FAO (1998) indicate that during 1997, outbreaks associated with the movement of livestock occurred at two locations in Thika and Machakos districts both of them close to Nairobi.

CBPP in Kenya has not yet been properly mapped, whereas the CBPP situation is dynamic resulting in a continuous rezoning for disease control purposes (Veterinary Department 1982 and 1998). The Kenya Ministry of Agriculture (MOA, 1994) lists research in control of CBPP as top priority among other diseases.

The eradication of CBPP from Africa faces many drawbacks (Masiga and Domenech, 1995; Egwu *et al.*, 1996):

- Traditional nomadic animal husbandry which favours the spread of the disease (Provost *et al.*,1987) and the use of antibiotics and traditional medicines which make the problem more complex and serious (Guadagnini *et al.*, 1991; Mlengeya, 1995; Bolske *et al.*, 1995).
- Short-lived immunity conferred by the vaccines, up to 8 months (Abdalla, 1975), up to 12 months (Atang, 1968 and 1969; Dyson and Smith, 1975) and up to 2 years (Masiga and Domenech, 1995).
- Following vaccination some animals contract CBPP as a direct vaccination effect or as a reactivation of a latent case while others elicit unacceptable adverse reactions (Provost *et al.*, 1987).
- Carriers are difficult to detect as the OIE recommended test, CFT, is of low sensitivity in detecting chronic carriers and the test is cumbersome and time consuming, requiring well

trained personnel (Bashiruddin *et al*, 1994a; Provost *et al.*, 1987)). Clinically, CBPP is difficult to diagnose such that it is often ignored or misdiagnosed as simple respiratory disease or some other disease (Blancou, 1996).

- Lack of proper mapping of the disease due to lack of precise knowledge on disease occurrence as a result of scarce human and technical resources (Lefevre *et al.*, 1993).
- Poor vaccination coverage in endemic and high risk areas due to high costs and nomadic movements (Egwu *et al.*, 1996).
- Inadequate disease reporting by farmers and sometimes slow or inadequate action from field veterinarians and private practitioners and the absence of early warning systems (FAO, 1997a).
- Lack of data on the economic impact of the disease (Masiga *et al.*, 1996)
- Continuing civil strive in some African countries and drought which have had a significant impact on the spread of CBPP due to the problems posed in control of cattle movements (Egwu *et al.*, 1996).
- Difficulties in controlling cattle movements, particularly in sub-Saharan Africa and the complications of applying quarantine and slaughter policies (Masiga and Domenech, 1994).
- Insufficient funds to implement CBPP programmes (Masiga and Domenech, 1994).

Following the assessment of the problems and prospects of CBPP eradication in Nigeria by Osiyemi (1981), one may agree with Curasson (1964) as quoted by Provost *et al.* (1987) that in regard to investigation and control, no disease is as misleading as CBPP.

However, Kenya had in place a well established CBPP control system which operated upon the following general lines (Kane, 1975):

1. Mass vaccination in endemic areas.
2. Field testing with slaughter of reactors within the endemic areas.
3. Rigid control of movement from infected to non-infected areas.
4. Rapid stamping out of any outbreaks that might occur outside the endemic areas and possibly vaccination of in-contact herds.

Due to lack of economic resources breakdowns in part of this system were encountered to the extent that the country has not been able to rid itself of the CBPP scourge. This study is to evaluate this control system and reach at recommendations on how to revamp the system and send CBPP in Kenya into the books of history.

Thus the objectives of this study were in particular:

1. To provide a summary of CBPP outbreaks based on reports and interviews.
2. To determine cattle movement patterns, both traditional and trade and relate them to disease outbreaks.
3. To determine the vaccination coverage within the country.
4. To map the disease and vaccinations using georeferenced mapping programmes.
5. To determine the factors affecting disease reporting by farmers.

2.0 LITERATURE REVIEW

2.1 The history and distribution of CBPP

CBPP is widespread in Africa and is recognised to be present in some countries of Asia and Europe. CBPP appears to have existed in the ancient world according to early classical writings (Provost *et al.*, 1987). The clinical signs of CBPP were described for the first time by Bourgelat in 1765 who distinguished CBPP from other diseases of the lung. The first recognition and awareness of CBPP dates back to 1773 when mass slaughter was recommended for its control. With greater cattle movements in the early 19th century caused by Napoleonic military campaigns and the general increase in international cattle trading, CBPP spread rapidly throughout Europe.

2.1.1 CBPP in Europe

After virtual elimination from Europe in the 19th Century the disease reappeared in Portugal where it persisted until as late as 1958 in the Iberian peninsula (Ferronha *et al.*,1990). Further outbreaks occurred in 1961 in Spain and then in France in 1967 (Anon, 1967). The latest outbreak in France was reported in 1984 (Provost *et al.*, 1987) where mortalities were recorded in three herds (ter Laak, 1992). Infection was reported to be widespread in Portugal in 1983 with serological evidence suggesting that the disease had been present for months and may be years. CBPP is now endemic in North western parts of Portugal around Porto but outbreaks have decreased significantly in the last few years. Spain began reporting cases of CBPP as from 1989 annually. In 1990 Italy reported its first outbreak for over 100 years. The disease quickly spread from the north to most of Italy. However, as a result of abattoir surveillance, movement control linked to serological monitoring, and slaughter of infected and in-contact animals, no cases have been reported in Italy since 1993 although the occurrence of seropositive animals remains a problem (Egwu *et al.*, 1996). The epidemiological situation in Eastern European countries is still unknown.

2.1.2 CBPP in Asia

Very little data exist for the prevalence of CBPP in the Middle East and the rest of Asia. In recent times the disease has been reported from Assam in India, Bangladesh and Myanmar (Choudhary *et al.*, 1987). It is believed that sporadic outbreaks are still occurring in the Yemen, United Arab Emirates, Saudi Arabia, Katar, Kuwait and Lebanon mainly as a result of cattle importations from Africa (Lefevre, 1991; ter Laak, 1992). Jordan is also thought to be infected (Mlengeya, 1995).

2.1.3 CBPP in Africa

In the first years of this century, CBPP was widespread among the pastoral areas of East and West sub-Saharan Africa. However, control measures including vaccination campaigns and control of livestock movement successfully eradicated the disease from most of the continent so that by 1970 CBPP was confined to the Horn of Africa, some parts of West Africa and Angola (FAO, 1997a).

Civil disturbances in Ethiopia and the Sudan have subsequently reduced the effectiveness of these control measures, particularly the control of livestock movement, so that in the last decade the disease spread back into Uganda (1979), Kenya (1987), the Ituri Region of the Democratic Republic of Congo and into Tanzania (1990), Rwanda (1995) and Burundi (1997). During the last two years infected animals have moved along trade routes into southern Tanzania where the disease had been absent for 25 years (Bolske *et al.*, 1995); outbreaks of the disease have occurred there threatening Zambia, as reported in 1997, Zimbabwe, Malawi and Mozambique.

On the other hand, disturbances in Angola have led to the migration of affected cattle into Namibia (1982) (Trichard *et al.*, 1989), where the incidence of the disease was reported as low, and very recently across the Caprivi strip into Botswana (1995) where the disease had been absent for 56 years (Amanfu *et al.*, 1998a). South Africa, the Gambia, Senegal, Malawi, Zimbabwe and Swaziland are purportedly still free of CBPP (ter Laak, 1992; OIE, 1993). The status of the Central African Republic and Mozambique is unknown because there are no resources for surveillance (OIE, 1993).

2.1.3.1 CBPP in Kenya

The history of CBPP in Kenya has been reported by Kariuki (1971) only up to 1970. It is not known when the disease was introduced into Kenya although some sources (Davies, 1991) state that after its arrival in South Africa from Europe, CBPP spread into East Africa by Boer settlers who trekked their cattle to the Kenyan highlands around the turn of the century. Others believe that it may have been present in precolonial times and cite Thompson's description of a cattle disease resembling CBPP in Maasai cattle in the 1880s in East Africa (Davies, 1991). It is apparent that CBPP was widespread in Kenya for the first 70 years. A full report on the CBPP situation in Kenya during this period is to be found in Annex 10.

1971 – 1988

No other comprehensive documentation has been made except that found in annual departmental reports and an unpublished update (Wandaka, 1990). The zoning of the country from 1975 to 1982 (MOA, 1975) is indicated in Annex 1c.

In 1972 an outbreak was recorded in Wajir District and in 1975 a fresh outbreak was recorded in Lamu district. A suspected outbreak in Wajir district in 1976 was never confirmed. CBPP was confirmed in Busia, Bungoma and Siaya districts in 1980 and in 1981 an outbreak was confirmed in Trans-Nzoia district which was traced back to cattle purchased from West Pokot District in which the disease was confirmed in the same year. 1986 saw the introduction of CBPP into the Central Province in Muranga district following the purchase of ex-Garissa cattle from Thika municipality in Kiambu district where the disease was also confirmed in the same year and later,1988, reported in Ruiru location of Kiambu district. In 1986 the disease was introduced into Kajiado district following purchase of ex-Isiolo district cattle by farmers from KMC's Beacon ranch in Athi River. Two outbreaks in Kitui and Machakos districts which affected several farms and ranches occurred in the same year. By testing and slaughter, CBPP outbreaks which occurred in Laikipia district between 1986 and 1988 were brought under control.

2.2 Contagious Bovine Pleuropneumonia (CBPP)

2.2.1 Description of the aetiologic agent

The mycoplasma causing CBPP belongs to the class Mollicutes, order Mycoplasmatales, family Mycoplasmataceae, genus Mycoplasma and species *Mycoplasma mycoides* subspecies *mycoides* small colony variant (*Mmm*SC) (Nicholas and Bashiruddin, 1995).

Mycoplasma organisms are highly pleomorphic and plastic due to the fact that they have no cell wall. They have a lipoprotein plasma membrane and occur in a variety of forms including spherical, pear-shaped and filamentous and range in size from 0.2 to 0.8 μm in diameter. (Egwu *et al.*, 1996). The genome is a double stranded DNA molecule (Egwu *et al.*, 1996). They stain poorly with Gram stain although Giemsa staining is useful.

2.2.2 Definition

CBPP is a contagious disease of cattle and water buffalo caused by *Mycoplasma mycoides* variety *mycoides*, small colony biotype (*MmmSC*) (Bashiruddin *et al.*, 1994a). The disease is characterised by fibrinous interstitial pneumonia, pericarditis and pleurisy with a morbidity of up to 70% and a mortality rate of approximately 60% (Brocchi *et al.*, 1993; ter Laak, 1992; Provost *et al.*, 1987). There is also involvement of thoracic lymph nodes (Scanziani *et al.*, 1997).

In Europe, unlike in Africa, the disease is characterised by low morbidity and almost non-existent mortality with the majority of cattle showing chronic lesions. These differences are, in part, due to the fact that European cattle are healthier, better fed, subjected to less physical stress and are often permanently housed throughout the year (Nicholas and Palmer, 1994).

2.2.3 Clinical picture

There is considerable variation in the degree of symptoms seen in cattle affected with CBPP ranging from hyperacute through acute to chronic and subclinical forms. Respiratory distress and coughing evident on the stimulation of resting animals are the main signs of CBPP (Scudamore, 1995).

The incubation period of the natural disease may range from 5-207 days (Martel *et al.*, 1983) although Turner and Campbell (1937) reported a range of 29-58 days and Provost *et al.* (1987)

stated 20-40 days while Masiga *et al.* (1996) reported three to six weeks or longer for natural infection and about three weeks for experimental infection.

Experimental reproduction of the disease is difficult but is best achieved by bronchial intubation or aerosal inhalation of low passage *MmmSC* (Gourlay and Howard, 1982; Martel *et al.*, 1983); Regalla *et al.*, (1994) reported disease symptoms appearing in cattle 40 days after contact with inoculated animals and lasting 20 days.

In endemic regions, 13% of cases are of hyperacute form, 20% of the acute form and 46% of the sub-acute form. Approximately 21% of animals are resistant to the disease
(Masiga *et al.*, 1996).

Hyperacute form

This form occurs during the onset of an outbreak and death may be all that is seen. In some cases the animal may die after one to three days with no signs of pneumonia. Death may result from asphyxia, toxaemia or heart attack (Masiga *et al.*, 1996).

Acute form

This form has a course of five to seven days. The early stages of the disease are indistinguishable from any severe pneumonia with pleurisy (Scudamore, 1995). The earliest signs are a sudden onset of fever to 40-42^{0}C or more and in milking cows a drop in milk yield. Sick cattle tend to isolate themselves from the herd and stop eating. There is dullness and irregular rumination. Cough is usually persistent and is moist or dry and may be painful. The animals are listless with a staring, lustreless coat; they also become emaciated (Seifert, 1996). The animal prostrates with difficulty of movement. As the lung lesions develop the symptoms become more pronounced with increased frequency of coughing; the animal may stand with back arched, head extended and elbows abducted. There is dilation of nostrils and the mouth is open panting for air. A typical respiratory disease is evident; breathing is laboured and obviously painful. Abdominal breathing with increased respiration may be seen and cattle may grant when breathing out.

Application of pressure between the ribs is painful and resented by affected cattle which sometimes react violently. On percussion, the ventral part of the chest sounds dull owing to the presence of fluid in the chest cavity.

There maybe nasal discharge sometimes streaked with blood and frothy saliva accumulates around the mouth. Some animals develop swellings of the throat and dewlap. Pregnant animals may abort and diarrhoea has been recorded. If the animal survives the disease turns chronic and clinical recovery is only apparent.

Subacute and chronic forms

The subacute form occurs in about 40-50% of the animals affected and up to 25% of these cattle become chronic carriers which are often referred to as lungers and believed to play a role in initiating new outbreaks when they are moved into susceptible herds. This proportion is probably higher in Europe where there is a far more widespread use of antimicrobials (Nicholas and Palmer, 1994). The use of antibiotics and antiinflammatory drugs may help to mask clinical signs and to accelerate the formation of chronic lesions. In Italy, during the 1990s, less than 5% of cattle in an infected herd showed clinical signs (Guadagnini *et al*., 1991).

Symptoms may be limited to a slight cough only noticeable when the animal is exercised, to intermittent fever and chronic emaciation (Blancou, 1996). Regeneration of the lesions may occur after several weeks, but full recovery is exceptional. Sequestral lesions and pleural adhesions remain. On the other hand Masiga *et al*. (1996) believe that after about 36 months the lung lesion may get sterile and depending on its size there might be complete healing.

CBPP in calves

While classical respiratory signs may be evident in calves, articular localisation of the causative agent and arthritis usually predominate. Complications accompanying the disease may also include vulvular endocarditis and myocarditis (Martel *et al*., 1983).

2.3 Pathology of CBPP

2.3.1 Macroscopic lesions

The pathological lesions of CBPP are confined to the thoracic cavity and lungs. In a study of 566 CBPP affected lungs in Portugal, Nunes Petisca *et al*. (1990) showed 95% of the lesions to be unilateral which contrasts with infections caused by *P. haemolytica* where both lungs are usually affected. The diaphragmatic lobe was observed to be more commonly affected than the cranial lobe. The thoracic cavity may contain several litres of a clear yellowish-brown fluid containing 'omelettes' of fibrin (ter Laak, 1992). The interlobular septae of the affected lung show distension with amber coloured fluid surrounding the distended lymphatics. This fluid separates the lung lobules which vary in colour with red, grey and yellow hepatization being evident indicating different stages of inflammatory lesions (Hudson, 1971). Consolidation of the lungs with typical marbled appearance, sometimes accompanied by adhesions of the parietal and visceral surfaces is also characteristic. In chronic or advanced cases, a sequestra consisting of necrotic lung parenchyma surrounded by a fibrous capsule is formed (Santini *et al.*, 1992). In addition to respiratory form, affected calves may present exudative peritonitis, arthritis, bursitis and fibrinous arthritis of the carpal and tarsal joints (Provost *et al.*, 1987). Often enlargement of the suprascapular lymphnodes and kidney infarcts (FAO, 1997b) may accompany these changes.

2.3.2 Histopathology

In the early stages, the CBPP lesion comprises a bronchiolar necrosis and oedema, progressing rapidly to an exudative serofibrinous bronchiolitis with extension to the alveoli and uptake of alveolar fluid into tissue spaces, lymph vessels and ultimately septal lymphatics (Done *et al.*, 1995). The mediastinal, sternal, aortic and intercostal lymph nodes may become enlarged, edematous or even haemorrhagic. With stasis lymph vessels become thrombosed and ultimately fibrosed (Buttery *et al.*, 1980). The pulmonary lobules become consolidated with alveolar edema, fibrin and inflammatory cells. Coagulative necrosis is common. *MmmSC* can be demonstrated in these lobules by immunohistochemistry. Perivascular organisation foci found in the interlobular septae are considered pathognomonic for CBPP (Ferronha *et al.*, 1988). Scanziani *et al.* (1991) in an immunocytochemical study of CBPP infected Italian cattle showed that the severity of lung lesions correlated with the severity of changes in the lymph nodes. Infiltration of neutrophils and macrophages have been reported (Provost *et al.*, 1987; Egwu *et al.*, 1996).

2.4 Diagnosis

2.4.1 Clinical diagnosis

Clinical diagnosis of CBPP is not particularly difficult in the acute form, but it can be difficult in subacute forms and completely impossible in the case of chronic carriers (Lefevre, 1994).

Furthermore, the use of anti-microbial or anti-inflammatory drugs can mask the clinical expression of the disease (Egwu *et al.*, 1996).

2.4.2 Postmortem diagnosis

At post mortem examination or at the abattoir, the lesions are very characteristic when acute exudative forms or chronic forms are present. Postmortem diagnosis is therefore relatively easy, particularly within a relevant epidemiological context. However, subacute forms here again pose problems as the lesions can be confused with those of pasteurellosis or East Coast fever (Lefevre, 1994).

In carrying out a clinical and post mortem diagnosis, it is necessary to differenciate CBPP from other diseases, which may present similar clinical signs or lesions (FAO, 1997b).

2.4.3 Differential diagnosis

The confusion with Rinderpest results from the fever and discharges observed from the eyes, nose and mouth and lung lesions at postmortem. However, the characteristic lesions of rinderpest which are essentially erosions in the mouth and throughout the digestive tract, together with the profuse, often bloody, diarrhoea in advanced cases should enable easy differenciation with CBPP in which they are not seen (FAO, 1997b).

In foot and mouth disease, salivation, lameness and fever may pose a cause of confusion.

Haemorrhagic septicaemia is a very acute disease, and buffaloes are particularly susceptible. The lung lesions seen in animals that survive longest can appear very similar to the marbling lesions of CBPP. There may be yellow fluid in the chest and the affected lung may adhere to the inside of the rib cage. Thus, in an individual and single case distinguishing between haemorrhagic septicaemia and CBPP can be difficult (FAO, 1997b).

In bacterial or viral broncho-pneumonia clinical signs may resemble closely those of acute CBPP (Harwood *et al.*, 1995). However, post mortem examination shows usually both lungs to be affected, fibrinous exudate may be present but not to the same extent as in CBPP. While dark, solid lung areas may be seen, these are usually restricted to the anterior lobes (not the diaphragmatic lobe as in CBPP), and marbled lungs are rarely seen (FAO, 1997b).

Coughing, nasal and ocular discharge and diarrhoea are a source of confusion with East Coast Fever. However, affected cattle show general enlargement of superficial lymph nodes and especially those of the head. The lungs contain much clear liquid which is also present in the chest cavity; the airways in the lung may be filled with white froth and cigarette-burn-like ulcers are seen in the abomasal folds. Neither pneumonia nor inflammation of the pleura are seen (FAO, 1997b).

With bovine emphemeral fever, confusion with CBPP arises from the presence of fever, discharges from the eyes and dripping of saliva from the mouth, lameness and swollen joints, however in all ages, unlike CBPP (FAO, 1997b).

Abscesses may be mistaken for sequestra. A total destruction of the lung tissue occurs. Old thickly encapsulated hydatid cysts can also cause some confusion. Actinobacillus lesions are generalised and seldom present in lungs but when found, could be mistaken for sequestra (FAO, 1997b).

In tuberculosis the tubercular nodules can superficially resemble sequestra. The capsule of the tubercular nodules is not well defined when compared to that of sequestra besides the same lesions are seen in the lymph nodes in the chest, a feature not seen in CBPP.

When pericarditis is considered as the major presenting sign, foreign body pericarditis resembles CBPP clinically and pathologically except that in the former, only one animal is usually affected (FAO, 1997b).

The lung lesions of farcy differ from sequestra as they are filled with foul smelling purulent material as described for abscesses. Similar lymph node lesions are always present (FAO, 1997b).

2.4.4 Laboratory diagnosis

Laboratory testing is indispensable whenever CBPP is suspected (Lefevre, 1994).

2.4.4.1 Culture

The isolation of *MmmSC* from infected animals is essential for the successful diagnosis of CBPP. While there are few intrinsic problems with the growth of laboratory adapted *Mmm*SC strains, in practice detection rates of strains by culture frequently underestimate the levels of infection (Miles, 1992). This is due to a number of factors: relatively poor survival of mycoplasma during transport; the poor adaptation of some fresh isolates to in-vitro culture, and to the widespread use of antibiotics which can severely reduce the number of viable organisms in samples.

Isolation of *MmmSC* is followed by the identification of the pathogen through examining its biochemical properties with serological confirmation, by growth inhibition and/or immunofluorescence tests with monospecific conjugates (Freundt *et al.*, 1979). *MmmSC* requires a large number of aminoacids reflecting its limited synthetic capability; *Mmm*SC is referred to as fermentative because it produces acid from glucose metabolism. Glucose supports higher growth rates than did other sugars (Miles *et al.*, 1986; Miles, 1992). *MmmSC* is facultatively anaerobic, growing well in both anaerobic and aerobic environments at a pH of 7.6-7.8. Gentle aeration increases growth rate and yield (Rodwell and Mitchell, 1979). To avoid growth of other bacteria, inhibitors such as penicillin and thallium acetate are necessary. The medium can be used as broth or solid medium with 1.0 to 1.2% agar (OIE, 1996; Tulasne *et al.*, 1996). In actively growing cultures, *Mmm*SC is filamentous; at the end of growth, however, short beaded filaments predominate and ultimately only coccoid forms are seen (Razin, 1978).

2.4.4.2 Serology

Among the diseases investigated in veterinary medicine, CBPP is one of the best understood from the serological aspect (Gourlay, 1983; Perreau, 1975). Numerous serological tests have been described over the last century. These include the slide agglutination (Priestley, 1951), complement fixation (CFT) (Campbell and Turner, 1953), agar gel precipitation (Gourlay, 1965) and passive haemagglutination (PHA) (Chima and Onoviran, 1982) tests.

Detection of circulatory antigen

The double agar gel immunodiffussion test (AGID) is a simple test that can be applied in the field (Ameh *et al.*, 1995). The test most often detects galactan (Shifrine, 1967). The result is read after 24 hours of diffusion. For field use there is a simplified technique using thick discs of filter paper (Provost, 1972). It is also possible to test organ homogenates. Interfacial precipitation in liquid medium can also be performed. A positive reaction provides proof of infection. Circulatory antigen is most likely to be detected 6-10 weeks after the onset of the disease beyond which the frequency of detection diminishes sharply, and particularly in chronic carriers (Gourlay, 1965).

Detection of antibody

Slide agglutination test

The slide agglutination test is the quickest way of detecting antibodies when performed with stained antigen (Newing and Field, 1953). The reliability of the test is excellent during the acute phase of the disease but declines rapidly when the disease enters the chronic phase (Gourlay, 1965). Nevertheless the test retains its value when applied on herd level, as an infected herd contains animals at all stages of the disease; it should not be used to test individual animals.

Complement fixation test (CFT)

The Campbell and Turner CFT is still the procedure recommended by the OIE (OIE, 1996) The CFT as a micromethod has been harmonised in the European Union (Garrido Abellan *et al.*, 1993). Using the standard technique antibodies are detectable as from about 10 days after the onset of the disease and during the subsequent few months. The antibody profile following natural infection has not been properly studied. During the clinical stage of the disease the rate of detection is reliable and practically no sick animal will give a negative result. Results of subsequent surveillance using CFT, following an outbreak of CBPP in Italy in 1990, showed the specificity of the test to be 98% and sensitivity to be 63.79% (Bellini *et al.*, 1998). However for animals entering the chronic stage the percentage of false negative results increases (Gourlay, 1965) although Bellini *et al.* (1998) indicated that the sensitivity of CFT did not change significantly regardless of whether the lesions were caused by acute or chronic infection.
False positive reactions in the CFT are usually rare but have been recorded (Etheridge *et al.*, 1976). Such false positive reactions have been attributed to non-specific reactions caused by other members of the 'Mycoides cluster' and to a lesser extent by other related mycoplasmas (Chen *et al.*, 1985).

In countries where vaccination is practised, a presumptive diagnosis of CBPP cannot be made, because the CFT can yield positive results for 3-6 months after vaccination (Hudson, 1971). A field CFT is available (Huddart, 1963; Gourlay, 1983) for the screening of cattle leaving infected or potentially infected areas (Scudamore, 1975). However, the best working conditions for the CFT can be fulfilled only in a laboratory but the CFT is still difficult to perform, requiring well trained personnel (Provost *et al.*, 1987; OIE, 1996).

Passive haemagglutination test

This test is described by Chima and Onoviran (1982). It is a very useful but overlooked screening test and is approximately 20% more sensitive than CFT; however it produces false positive results at a rate of 2% in disease free regions (Regalla, 1988).

Enzyme-linked immunosorbent assay (ELISA)

ELISAs are inherently sensitive and are already being used for diagnosis of CBPP. The automation of each step including reading of results makes ELISA readily reproducible, less labourious and of high sample throughput. Whereas the CFT detects mainly the antigalactan antibodies, ELISA detects all antibodies to CBPP when the antigen consists of a lysate of *Mmm*SC. Another advantage of ELISA is that it improves the detection of chronic cases thanks to the high sensitivity of the method which is capable of detecting even traces of antibodies (Provost *et al.*, 1987).

In an extensive evaluation of an ELISA with a sonicated antigen, Le Goff (1986) showed a clearer distinction between infected and uninfected cattle compared to that shown by Onoviran and Robinson-Taylor (1979).

The agreement between the CFT and the cELISA in a sero-prevalence study and in a vaccination trial in Ethiopia has been rated as poor to moderate (k=0-0.78) (Takele, 1998). According to Le Goff and Thiaucourt (1998), the two tests correlate well with relative specificity and sensitivity of more than 90%.

Egwu and Aliyu (1997) have reported that their serological assessment on camels indicated that ELISA was more sensitive than dot enzyme immunoassay, western blot and CFT. On the other hand Nicholas *et al.* (1996) have reported their finding that ELISA was the least sensitive when compared to CFT, western blot and dot blot. In a field validation of a competitive ELISA (cELISA) for the detection of CBPP in Botswana during the recent outbreak, Amanfu *et al.* (1998b) indicated a specificity of 99.9%; much higher than that of CFT. Good performance in terms of repeatability, user-friendliness and the possibility to monitor a quality control programmme through the use of internationally developed software such as the ELISA Data Interchange (EDI) are the main advantages of this new serological tool when compared to CFT (Amanfu *et al.*, 1998). It is expected that in the near future the cELISA will permit a better assessment of CBPP in various regions of Africa and thus provide more accurate information for decision-makers to define the best cost- effective control strategies.

Polymerase chain reaction (PCR)

The development of PCR has provided a powerful tool which not only distinguishes the *M. mycoides* subspecies from the other members of the cluster, but also detects DNA from small numbers of organisms present in nasal mucous, pleural fluid and pulmonary tissue (Bashiruddin *et al.*, 1994a, 1994b; Hotzel *et al.*, 1996). Pleural fluid is the ideal diagnostic material on which the PCR can be carried out without DNA purification (Nicholas and Bashiruddin, 1994). These PCR based assays are specific, sensitive and rapid (Dedieu *et al.*, 1994; Hotzel *et al.*, 1996).

Immunodiagnostic tests

Immunocytochemical tests used by Ferronha *et al.* (1988) and Scanziani *et al.* (1991) to detect *Mmm*SC in tissue sections, provide valuable confirmatory data after slaughter. Immonocytochemical examination was used to confirm the presence of *Mmm*SC in the lung of domestic buffaloes which had been housed with infected cattle in Italy (Santini *et al.*, 1992). Immunocytochemistry is labour intensive but can provide valuable confirmation of CBPP in animals that die suddenly from acute respiratory disease.

Immunofluorescent staining can often provide a less ambiguous diagnosis of CBPP than peroxidase staining. In a study of 266 lungs from a naturally infected herd of cattle, Trichard *et al.* (1989) found immunofluorescent staining of impression smears to be more sensitive and far quicker than culture.

2.5 Epidemiology of CBPP

2.5.1 Aetiology

The aetiological agent is a member of the so called "mycoides cluster", a taxonomic grouping of six closely related mycoplasms which are all pathogenic to some degree in ruminants (Egwu *et* *al*., 1996).

2.5.2. Pathogenicity of aetiologic agent

The pathogenicity of *Mmm*SC, a pneumotropic microorganism strictly adapted to bovines, can be measured accurately under well-controlled conditions only by aerosol administration into the bronchi of animals previously unexposed. In this way the strains may be classified as hyper- or hypovirulent, requiring inocula of 10^2 and 10^9 mycoplasmas per ml of culture respectively. In addition, a test for mycoplasmaemia in mice may be a helpful, particularly in identifying vaccine strains (Provost *et al*., 1987).

However, inoculation experiments have to take into account a certain number of virulence factors inherent to the organism itself such as strain, colonial morphology, number of subcultures and age of the culture. Animal experiments enable large-scale verification of the slight but well – attested nuances associated with differing degrees of virulence in strains responsible for the naturally occurring disease (Provost *et al*., 1987).

In countries or regions infected for some years, CBPP takes an enzootic form with isolated cases, usually subacute. When introduced into the country for the first time, the disease tends to spread rapidly like an oil spot on water, resulting in numerous foci in which many animals become infected and develop the acute clinical form. Symptoms observed decline in severity proportional to the time that the disease has been present in a herd or in a region. Strains of the causal agent vary in pathogenicity and infectivity in different epidemics and in the same epidemic depending on the moment of isolation. Within a given herd, the disease has a more explosive character at its onset than at its end, and the decrease in pathogenicity can be reproduced experimentally (Provost *et al*., 1987).

Within a given region, all animals in infected herds die at the onset of infection but many recover at the end of the epidemic. The last strains to be isolated are of lower virulence than the first strains. Tests conducted during different epidemics give results which agree with clinical findings. It is possible to distinguish very virulent, velogenic strains such as the Gladysdale strain, from hypovirulent, mesogenic or lentogenic strains such as the Mara, Oremit and V5 strains (Provost *et al*., 1987).

Filamentous comet – shaped forms seem to have been wrongly considered the only virulent forms, because corpuscular forms behave in an identical manner at the same stage of subculture. Furthermore, contrary to the general rule of bacteriology, S-forms do not appear to be hypervirulent in comparison with the R- forms of dissociation.
Broth cultures of a freshly- isolated strain are undeniably the most virulent, while during the various passages, subcultures undergo a degradation of their pathogenicity when administered into bronchi or subcutaneously. Application of this rule in vaccine preparation verifies its authenticity. Nevertheless it is difficult to state, even for a given strain cultured under the same conditions, that virulence will be attenuated to the same degree after the same number of passages (Provost, *et al* 1987).

The role of capsular-like structure, galactan, seen in *Mmm*SC is poorly understood in the development of the disease although it has been shown to cause necrosis and marked tissue reaction in the absence of causative mycoplasmas (Buttery *et al.*, 1980). Nicholas and Bashiruddin (1995) have suggested that the accumulation of mycoplasmal metabolites may contribute to the cytopathic effects and tissue damage. It has also been suggested that the development of lesions are an effect of the direct multiplication of inhaled infective droplets and immunological reactions (Masiga and Domenech, 1995).

Considerations have been made into the antigenic similarity between the *Mmm*SC galactan leading to autoimmunity and the normal bovine lung tissue pneumogalactan (Gourlay and Shifrine, 1966; Kakoma *et al.*,1973). This, as has been suggested, could trigger an autoimmune reaction with immune complexes precipitating around capillaries as shown by immunochemical studies (Ferronha *et al.*, 1988). The resultant effect is that pulmonary cells and capillaries are damaged and show a characteristic Arthus type anaphylactic reaction.

No toxigenic effects have yet been linked with the galactan component of *Mmm*SC but toxic induced inflammatory changes including thrombocytic effects on capillaries have been reported (Egwu *et al.*, 1996). However, widespread thrombosis seen in goats infected with *Mmm*LC could be attributed to an unidentified endotoxin, an observation which was further substantiated by adhesion studies of *Mmm*SC on endothelial cells and subsequent cytotoxic effects on these cells (Valdiviesco-Garcia *et al.*, 1989a, 1989b)

Resistance of the pathogenic agent

The resistance of *Mmm*SC to environmental factors is low and the agent is capable of surviving for only 2-3 days in tropical regions, and rather longer (1-2 weeks) in temperate regions. Being unsporulated and without a cell wall for protection, *Mmm*SC has only slight resistance to high temperatures depending on the medium in which it is suspended.

By contrast, cold is an excellent preservative and the organism can survive for at least a year in frozen, infected lungs. As a rule, broth cultures can be stored for 2-4 months at 4^0C, and this affords an approach which can be applied to vaccines (Provost *et al.*, 1987).

The freezing of cultures has no immediate harmful effect. Paradoxically, it may even enhance the titre of cultures. A temperature of -20^0C, or better still -30^0C or -70^0C enables the organism to be kept for several years, although the titres drop by 1 or 2 log units. Lyophilisation can be used to preserve the organism (Provost *et al.*, 1987).

Ultraviolet radiation inactivates cultures within a few minutes. Sunlight has little effect providing the container cuts out ultraviolet light and the temperature within the container does not rise above 45^0C.
The organism is inactivated in a few minutes by exposure to ultrasonic oscillations.

2.5.3 Modes of transmission

Source of infection

The chief type of infective material is the pleuropneumonia "lymph" which exudes from the cut lung or accumulates by exudation within the pleural cavity. In acute forms of the disease, the excretion of infective material is considerable and continuous; in subacute and chronic forms, excretion is less abundant, irregular and sometimes absent (Provost *et al.*, 1987).

While respiratory excretion is the prime source, there is a certain degree of mycoplasmaemia during the early febrile stage, which renders other organs infective such as the brain, liver, kidney, lymph nodes, uterus, foetus and foetal membranes. In this respect urine may also be important, as considerable numbers of MmmSC have been recovered from urine (Masiga *et al.*, 1972b; Provost *et al.*, 1987).

Mycoplasma mycoides var. *mycoides* was isolated from ticks collected from Kenyan cattle clinically infected with CBPP. Experiments with nymphal and adult ticks collected from cattle experimentally and naturally infected with the disease that were placed on uninfected cattle showed that the ticks were unable to transmit the disease (Shifrine *et al.*, 1972).

In the chronic carrier state, the frequently occurring clinical recovery is generally accompanied by the sequestration of lung and pleural lesions, with perivascular cellular organisation and formation of a fibro-sclerotic external barrier. The lesion is still active immunologically, providing the immunity of superinfection, together with tuberculin-type delayed hypersensitivity. Sequestra are usually closed but an occassional pulmonary sequestrum may open into a draining bronchus, with the dangerous epidemiological consequence of carriage and excretion of the causal agent. The cycle of infection is completed when the carrier emits aerosols of the causal agent, exposing disease-free animals in contact to repeated possibilities of infection (Lloyd and Etheridge, 1983; Provost *et al.*, 1987).

Modes of infection

The disease is transmitted by direct contact, and over small distances by the coughing animal, emitting droplets from the mucous membrane of pharynx, trachea and bronchi and from saliva, or even micro-droplets of urine transported by an air current (Masiga *et al.*, 1972). There are minor departures from this rule which include experimental transmission by infective aerosals over a distance of 20m or more (Provost *et al.*, 1987), 50 to 200 meters transmission across a double barbed-wire fence (but with a favourable wind) (Masiga *et al*,. 1996) and an example of infection between shipments of cattle by truck. The infection is facilitated by crowding of animals around watering places or in a pen or paddock (Seifert, 1996; Masiga *et al.*,1996). Communal fences have been shown to be important contact points for the spread of CBPP (Trichard *et al.*, 1989).

2.5.4 Host susceptibility

Species

Under natural conditions, CBPP primarily affects cattle but also occurs in related animals including buffalo, yak, bison and even reindeer (Hutyra *et al.*,1938).

Bos taurus and *Bos indicus* are equally susceptible (Masiga and Windsor, 1974 and 1975; Masiga *et al*., 1996). In Africa the more frequent involvement of zebu is an epidemiological rather than an aetiological factor, as the disease is more serious among large zebu herds in the interior of the continent than among small exotic herds near the coast.

Many of these reports have not been substantiated; indeed Provost (1988) reviewing the literature, could not find evidence to show that domestic buffalo, (*Bubalus bubalis*) was susceptible under natural or experimental conditions. Experimental work in Australia showed that buffaloes could be infected by artificial means but did not spread CBPP to in-contact buffaloes (Newton, 1992). However, Santini *et al*. (1992 discovered pulmonary lesions and isolated *Mmm*Sc from seropositive buffaloes which had been in contact with CBPP affected cattle in Italy. They concluded that buffaloes were susceptible albeit at a low level. The African wild buffalo (*Syncerus caffer*) is not susceptible (Shifrine and Domermuth, 1967).

Small ruminants, in particular goats, have been shown to harbour the causative mycoplasma (Hudson *et al*., 1967). However, Egwu *et al*.(1996) have reported that sheep and goats are susceptible only under experimental conditions. Recently Brandao (1995) isolated *Mmm*SC from the milk of sheep with mastitis as well as from goats with pneumonia in Portugal outside the endemic area of CBPP. In 1986, Okoh and Ocholi isolated *Mmm*SC from an outbreak of disease in sheep in Nigeria. These reports pose serious implications for CBPP free countries importing small stock from such regions.

Paling *et al*. (1988) carried out a serological survey of camels for CBPP and found that just over 60% showed significant antibody titres. They were, however, unable to isolate *Mmm*SC from the assymptomatic camels and it is therefore unclear whether these animals may pose a risk to cattle.

Breed

Some breeds of zebu are remarkably resistant to naturally occurring CBPP, such as Somba, the breed of coastal Benin, and the small Cote d'Ivoire breed; however, they develop particularly severe reactions to the inoculation of infective "lymph" or strains of *M. mycoides* which are still pathogenic.

The Maasai breed of Tanzania is equally resistant, and 80-85% of them recover without treatment, whereas the European breeds and their crosses are more receptive. In Zambia there is a high degree of infection among Barotse and Mashululumbive breeds, while in Sudan, by contrast, almost 40% of zebus are resistant to experimental infection. In Europe, during the previous century, the Dutch and Flemish cattle were more susceptible than Swiss, while in present day Kenya, Jersey cattle are affected more often than Friesians. N'dama cattle of Guinea seem to be more susceptible than the zebu and crossbred N'dama of Senegal (Provost *et al.*, 1987; Seifert, 1996). In Australia, dairy cows of Anglo-Normandy breeds were more susceptible to experimental infection than Hereford beef cattle (Provost *et al*, 1987).

Following vaccination and experimental infection, similar variations are observed, but it is not legitimate to separate one from the other, since in both the only effect is a Willem's reaction.

As a rule, exotic cattle are more susceptible than zebu at least in Africa. Contamination of the environment has been implicated in the apparently high resistance of zebu, which is believed to confer on progeny a certain acquired resistance, sustained by successive infections. (Provost *et al.*,1987; Seifert, 1996).

Age

The age of the animal has various repercussions in the naturally occurring disease and the response to vaccination. In the natural disease, the susceptibility curve is sigmoid in shape with three phases: an initial phase of low susceptibility, in unweaned animals, which develop only minor lesions of tendons and joints, and not the severe pulmonary form; a subsequent phase of moderate susceptibility, gradually increasing until 12-18 months of age, and a final phase of full susceptibility which explains the choice of cattle over two years of age for experiments on the virulence of *M. mycoides*, in order to eliminate aberrant responses (Provost *et al.*, 1987).

Similar variations are found in both experimental infection and vaccination. Willems, cited by Provost *et al.* (1987), stated that calves up to six months of age respond poorly to the inoculation of virulent lymph, developing no more than slight, transient oedema and that numerous cases of polyarthritis develop as a consequence. To this may be added cases of coronary valvular disease and myocarditis, encountered among calves less than three months old. At a later age, heifers respond weakly to vaccination but nevertheless become more resistant to experimental infection than adult cows. Zessin *et al.* (1985) in their analysis of baseline data in the Sudan indicate that older animals were found to be more likely seropositive using CFT than the younger group.

Cattle over three years of age are more resistant to CBPP than younger cattle as found by Masiga and Windsor (1978) in two separate experiments, and in a third in which different age groups were experimentally challenged and death considered the sole criterion of response. The explanation given was that aged cattle can resist better than younger cattle.

Manifestation of clinical disease appears to follow a certain pattern. Masiga and Domenech (1995) noted that young cattle suffer from articular forms while adult animals are more susceptible to pleuropneumonia. Provost *et al.* (1987) as cited by Nicholas and Bashiruddin (1995) have reported a higher seroprevalence in aged animals than in younger animals attributed to the maturation of the immune system as age increases.

Individual factors

Individual factors further complicate the multiple aspects of susceptibility. Thus, in South Australia it was found that aged dairy cows are more sensitive to both vaccination and challenge infection than steers from Central Australia; however, with numerous exceptions in the different groups. Such variation in the sensitivity of a group is far from remaining constant, and seems to follow unpredictable cycles. In addition, the kinetics of the disease in a herd extends over about 20 weeks (Provost *et al.*, 1987).

Group variation also has repercussions for vaccination, to the prejudice of statistical interpretation of results, because the same batch of vaccine inoculated into apparently similar cattle might provoke alarming, unforseen reactions in a given group, with a temporal evolution of vaccine reactions similar to that of responses to infection. Similarly, a group of cattle refractory to inoculation of vaccine might contract the disease a few weeks later. Instability in the receptivity is the major obstacle to vaccination against CBPP, which is based on an average receptivity of species, breed, age group and individual animal.

Favouring factors

Type of husbandry

The type of husbandry affects both epidemiology and aetiology, and may be the crucial factor since CBPP is essentially related to the movement of cattle. Areas completely free from infection can adjoin endemic areas if there is no movement of cattle between them. It is both true and false that CBPP is a disease of nomadic, or at least transhumant cattle.

In tropical Africa the disease occurs especially in that segment of farming populations and breeders living within the 500 isohyet, who have little experience in livestock husbandry. They thus contract herdsmen to send their cattle off to join the large transhumant herds of the Sahel. These newly introduced cattle are likely to pay a heavy toll to disease, revealing the existence of carriers in the nomadic cattle, and thus sparking off the disease in the reception herd. Further, commercial transactions involving Sahelian cattle, whether for slaughter, breeding or use for traction, are responsible for 'fresh' outbreaks. This establishes a surprising contrast between the apparent mild course and the low incidence of the disease among nomadic cattle on the one hand and the severity and catastrophic nature of the disease in areas populated by farmed cattle, on the other hand (Provost *et al.*, 1987).

Local husbandry practices in Sahelian Africa involve compact grouping of herds during grazing, mixing with other herds at watering points, and confinement at night within small enclosures. Such conditions are eminently favourable for infection. The intensity of infection is low in Sahelian regions, where herds are spread out, the air is dry and the sexes are kept separate. Under these conditions the disease may persist for a long time, only becoming evident when the animals are moved, new stock introduced or animals exchanged or traded between tribes (Seifert, 1996).

Climate and season

Climatic factors are more important for the way they affect the type of husbandry than any direct effect on the disease. According to Turner (1953) and cited by Provost *et al.* (1987), a dry climate diminishes the risk of spread, because infective aerosals from contaminated cattle evaporate rapidly, and the pathogen is inactivated by ultraviolet rays. With regard to the disease itself, once established and regardless of breed susceptibility, its severity is identical in dry or humid climates. Season seems to play a role in stimulating infection, particularly the rainy season, when the animals are exposed to cool downpours (Provost *et al.*, 1987). Sudden changes of weather have been cited frequently as important factors in the speeding up of disease and these may be more important than steady extremes of temperature and humidity, to which the animal may adapt. These changes may affect both the potential pathogen and the host (Dennis, 1986).

Intercurrent diseases

An intercurrent disease such as rinderpest in Africa frequently may result in a synergistic-pathogenic combination. Subsequent vaccination runs the risk of producing a similar situation. Thus, the use of caprinised rinderpest virus vaccine considerably increased reactions to CBPP. Similarly, anthrax vaccine can reactivate a weak Willem's reaction induced by an attenuated strain of *M. mycoides* with the development of a fatal Willem's reaction at the site of first inoculation, despite the presumed existence of immunity (Provost *et al.*, 1987).

Immunosuppression caused by trypanosoma infection has been reported. Cattle infected with *T. vivax* produce less CBPP complement fixing antibodies and 50% succumb to experimental CBPP infection when compared to uninfected controls (Ilemobade *et al.*,1982; Osiyemi *et al.*, 1985); thus, and it has been suggested that blanket treatment of cattle against latent trypanosomoses and endoparasites is important before vaccination against CBPP (Osiyemi *et al.*, 1985). In duly vaccinated herds the immunosuppressive effects of CBPP itself (Adegboye, 1978) and dermatophilosis (Chima *et al.*, 1986) can lead to insufficient response to the vaccine and outbreaks of CBPP upon challenge.

Immunity

Immunity in CBPP depends upon an interplay of humoral and cell mediated immune factors (Hudson, 1971). Both types of immunity have been used for diagnostic purposes: Serological tests, mainly CFT for detection of humoral antibodies, and skin testing for demonstrating cell mediated immunity (Lloyd, 1967; Etheridge *et al.*, 1976; Garba *et al.*, 1987a and 1987b and Regalla *et al.*, 1994).

The relative resistance in very young animals and the full susceptibility of adults has led to the vaccination of calves at three months, without an immune hiatus unfavourable for immunological cover.

2.5.5 Epidemiological markers

One of the major impediments to successful epidemiological tracing of CBPP outbreaks is the homogeneity of strains of *M. mycoides* subsp. *mycoides* SC. Costas *et al.* (1987) could not distinguish a total of four strains on the basis of Sodium-Dodecyl-Sulphate-Polyacrylamide Gel

Electrophoresis (SDS/PAGE) analysis. In a larger study, Goncalves *et al.* (1994) showed that 11 of 12 strains from a wide variety of sources were identical. Poumarat and Solsona (1995) analysed 46 *Mmm*SC strains by restriction enzyme analysis and showed that European strains had different patterns than African strains. Immunoblotting revealed that 22 of 24 Italian strains possessed a band of approximately 100kDa not present in other European strains suggesting that most of the Italian outbreaks did not originate from western Europe. Frey *et al.* (1995) and Cheng *et al.* (1995) recently described an insertion sequence, IS1296 which was present in 19 copies in the *Mmm*SC type strain PG1 but in lower copy number in *Mmm*LC and *Mycoplasma* sp. Bovine group 7. Over 60 strains of *Mmm*SC including vaccine strains were analysed with respect to the polymorphisms generated by variabilities in the copy number and chromosomal position of IS 1296. Ten different patterns were produced forming two main clusters comprising a European clonal lineage and one comprising strains from Africa and Australia. The possible implications of this work are: first, that recent European outbreaks arose from an established reservoir within Europe rather than as a result of importation from Africa; and second, that the African and Australian strains arose from strains which are no longer found in Europe (Egwu *et al.*, 1996).

2.6 Economics of CBPP

CBPP is economically the most important cattle disease in Africa, causing greater losses in cattle than any other disease including rinderpest (OIE, 1995). The direct losses according to Mlengeya (1995) are attributed to mortality, vaccination campaign costs, disease surveillance and research programmes. The indirect losses are mainly due to the chronic nature of the disease and include loss of weight and working ability, reduced milk yield, delayed marketing, reduced fertility, losses due to quarantine and consequent reduced cattle trade.

Based on cattle losses in 1991, Egwu *et al.* (1996) estimated direct losses in excess of 1.5 million dollars. The recent outbreaks between 1990 and 1995 in Tanzania have so far resulted in the deaths of 14,000 cattle valued in excess of one million dollars (Mlengeya, 1995). Giovani in a personal communication to Egwu *et al.* (1996) indicated that in Italy the cost of controlling the outbreaks between 1990 and 1993 was over 28 million ECU; over 24,000 animals including 1,200 buffaloes were slaughtered and full compensation paid.However, the cost of the 13 year eradication campaign (including research) costs in Portugal is said to be incalculable (Egwu *et al.*, 1996).

It should be noted that the economic evaluation of losses due to CBPP throughout Africa has not been performed systematically (Masiga *et al.*, 1996).

2.7 Control and Eradication

2.7.1 Zonation:

Zonation of a country with respect to CBPP is a prerequisite to institute the methods of disease control most applicable to the different zones. Criteria used to define areas of different epidemiological status include intensity of infection and recent disease history, natural boundaries, demographic and ethnic features, patterns of livestock movement and of trade, both legal and illegal. In such a dynamic situation, this zonation needs to be continuously reviewed and amended in every country as events dictate (FAO, 1996).

With respect to eastern and southern Africa, two zones are recognised: a CBPP infected zone and a CBPP free zone (FAO, 1996).

The CBPP infected zone includes the whole of Tanzania, Rwanda, Angola, Uganda, southern parts of Sudan, Ethiopia, Somalia, Kenya (including north of the 1^0 parallel in the districts neighbouring Sudan, Ethiopia and Somalia) and the Ituri district of Zaire.

The CBPP free zone includes Central province of Kenya, Burundi, Shaba district of Zaire, Malawi, Zambia, Mozambique, Namibia south of the cordon fence, Angola and Botswana as areas at high risk and Zimbabwe, South Africa, Swaziland and Lesotho as areas of lower, but still appreciable, risk.

If CBPP is not to make further advances into Southern Africa, measures must be taken which include the establishment of a cordon sanitaire (buffer zone) to separate infected and threatened territories, control programmes in the affected areas and CBPP preparedness measures in those areas that are presently clear of the disease but are under threat (FAO, 1997a).

The success of the CBPP eradication process in Australia was partly due to first delineating herds or regions where infection was known to be present or suspected and regions known to be free or presumed to be free. Based on the concept of Infected, Protected and Free Areas a logical system of movement controls was established (Clay and Lloyd, 1975; Gee, 1975).

2.7.2 Disease reporting

The reporting of outbreaks of epidemic diseases is often one of the weakest links in the chain of actions necessary to prevent, control and eradicate these diseases in many countries. Indeed in extreme cases outbreaks of serious epidemic livestock diseases in new areas have not come to the attention of central veterinary authorities for several months making control and eradication of the disease more difficult and expensive, or may be impossible. In addition, failure to report new disease occurrences to neighbouring countries and trading partners either directly or through international organisations such as the OIE and FAO leads to other countries being unable to take the necessary steps to prevent the introduction of the disease (FAO, 1997a).

Some of the common problems in early warning systems include (FAO, 1997a):

- Lack of farmer awareness programmes on high threat epidemic livestock diseases and generally inadequate contact between field veterinary staff and farmers;
- Disease reporting systems which are in effect passive rather than active in the form of disease surveillance;
- Inadequate training of veterinary and paraveterinary staff in the clinical and gross pathological recognition of epidemic diseases which may be either unusual or exotic for the country, the implications of delayed action, and the collection and transportation of appropriate diagnostic specimens;
- Poor condition of field and laboratory services;
- Lengthy and complicated routine disease reporting chains and failure to institute an emergency reporting system for serious disease outbreaks;
- Failure to establish confirmatory diagnostic capabilities for the target diseases within national laboratories;
- Inadequate liason with international reference laboratories and failure to send new strains from outbreaks to these laboratories on a regular basis for specialised antigenic and epidemiological analysis;
- Lack of an epidemiology unit and expertise to analyse new disease outbreaks, including traceback and traceforward activities;
- Failure to report new disease occurrences to the OIE with the recommended time;

- Lack of contingency planning and emergency preparedness for epidemic diseases. (FAO, 1997a).

2.7.3.The use of geographic information systems (GIS) as epidemiological tools.

Geographic information systems are computerised information systems that allow for the capture, storage, manipulation, analysis, display and reporting of geographically referenced data (Walsh, 1988). Essentially, the technique is a combination of computerised mapping technology and database management systems in which spatial data sets from different sources are managed and analysed (Sanson *et al.*, 1991).
There are few differences between a conventional information system and a GIS which can be identified at the input level, the analysis level and the output level. The inputs in GIS that are different from those in conventional information system are location information and digital map layer information, while at the analysis level, spatial statistical analysis is unique to GIS. Output in the form of thematic maps with their related attributes that can be manipulated by overlaying, alteration of scales, use of colour and other features, according to what one wants to demonstrate is unique to GIS (GTZ, 1995).

GIS is widely used in a number of disciplines, including utility management, urban and regional planning and marketing. A valuable role of GIS is to bring together many different disciplines (GTZ, 1995).

Several practical issues hinder the use of GIS as a 'pick up and use tool' in disease control (GTZ, 1995). These include:

- Lack of ready useable digitised maps. This may arise from maps being of wrong resolution, of different format from that required by the GIS software, too expensive, of poor production quality or have essential layers missing. Maps in some countries may be unavailable or not in the public domain as they are state protected;
- Lack of location information. Often disease reporting does not follow a specific pattern and even when it does it is often found that the location information is only available at e.g district level when what is required is farm level location data. One can then obtain the coordinates (location information) by the use of geographical positioning systems (GPS)

(GTZ, 1995). However, this requires one to go out into the actual location in the field and in the case of widely spaced-out locations, costs of travel may be prohibitive in addition to logistic limitations. The second option is then to use pre-existing paper maps to work out latitude and longitude (GTZ, 1995). This process is time consuming and often inaccurate due to the inadequacies of available paper maps. A pre-existing relational database can speed up the process. Usually, however, such a database does not exist or does so as personal property. The use of satellite imagery is as yet too expensive and requires too much technical knowledge to interpret and correct;

- Lack of standardised information sampling procedures. Procedures for the random sampling of information of relevance to animal health are poorly documented and proper development requires the collaboration between epidemiologists and spatial statisticians (GTZ, 1995);
- Problems of analysis. Epidemiologists look for patterns, both spatial and temporal in an attempt to link underlying causal factors with observed disease patterns. However, there are no standard spatial statistical analysis tools that may be understood or applied by most workers in the field of veterinary epidemiology;
- Problems of presentation of the output. In the case of a GIS, a major component of its usefulness is the ability to present the output in map form. This requires proper skills in graphic design, the use of shapes and colours and training in cartography. Sometimes maps produced under GIS may not only be unpleasing to the eye but can also be misleading especially to non-technical recipients who are familiar with neither the subject nor the inherent strengths and weaknesses of GIS (GTZ, 1995).
- Several GIS software is available for use among them ArcView, ArcInfo and MapInfo. Though the cost of software differs between the different packages, the cost of a GIS software can be prohibitive.

Inspite of the problems encountered with the use of GIS, and the fact that conventional analysis will be often sufficient to analyse and describe the required characteristics, the ability of the human brain to infer from visual images cannot be underestimated, and it is possible to use the graphic output of GIS to great effect especially when describing information to non-technical decision makers. It is for this reason that GIS is evolving into an important tool applicable to many aspects of disease control (GTZ, 1995). Indeed, GIS is currently in use in schistomiasis surveillance (Zhou *et al.*, 1999), determination of cost-benefit analysis of control of African animal trypanosomosis (Kristjanson *et al.*, 1999), epidemiology of vector-borne diseases (Kitron,

1998) and porcine foot and mouth disease (Yamane *et al.*, 1997). GIS has also been applied in tempero-spatial visualisation of disease outbreak dynamics (Cameron *et al.*, 1997) and spatial projection of socio-economic data in the strategic implementation of a livestock disease control intervention (Delehanty and Dvorak, 1993). GIS has not been used in any CBPP related work.

2.7.4 Methods of control and eradication

There are three methods of control (i) test and slaughter with (or without) compensatory payment, (ii) control of cattle movement, and (iii) vaccination.

Movement control and quarantine

It has been stated that CBPP would disappear from Africa if nomadism ceases (Provost *et al.*, 1987) and it is clear that pastoralism constitutes the major means of spread as e.g. observed with the Masai and Barbaigi of Tanzania (Mlengeya, 1995). However, restriction of movement is impractical in regions where livestock rearing constitutes a major livelihood for the nomads (Egwu *et al.*, 1996). Quarantine is a stricter form of movement control in which the infected and in-contact herds should be kept under constant surveillance so that clinical cases may be observed (Provost *et al.*, 1987). Movement control can, however, be applied to some extent by the issue of movement permits on well-known cattle trade routes and policing of such trade routes (DSE, 1980).

Slaughter of all sick and in-contact cattle (stamping-out)

This is the simplest and most effective strategy for disease control and essentially was used to rid Great Britain and USA of CBPP at the end of the 19th Century. However, it requires full co-operation from cattle owners and timely compensation payments to restock herds. This strategy is often impractical in developing countries under the present economic conditions. As in some European countries bureaucratic problems lead to delays in paying compensation political implications in the developed countries are contributing factors for the continuation of CBPP (Egwu *et al.*, 1996). In Africa, the stamping-out method can only be introduced at a later stage of the campaign after the CBPP incidence has been substantially reduced in such a way that the status of an enzootic zone is approaching that of a free zone (DSE, 1980). However, though it has been recommended that every effort should be made to move slaughter cattle by mechanical transport from place of origin to the abattoir (DSE, 1980), at present this seems to be illusoric.

Slaughter of sick cattle and vaccination of those in contact

A second strategy involves the slaughter of sick cattle and vaccination of those in contact (ring vaccination). Ring vaccination as suggested by Lindley (1973) should entail vaccination as soon as possible, of all cattle in an infected herd and all herds inside a circle of ten kilometre radius around the outbreak. Provost (1994) clearly stated that this frequently used method has always perpetuated CBPP wherever it has been used.

Due to high costs of slaughter this should be a strategy of last resort to be used in critical epidemiological situations such as in the case of outbreaks in a free area or the surveillance zone (of a cordon sanitaire) or on major trade routes (FAO, 1997a).

Preventive vaccination

Vaccination is the only realistic method of choice for CBPP control in endemic zones in Africa. Apart from the aborted JP-28 of the 80s in West Africa funded by the European Union there has been no systematic and well coordinated vaccination campaign against CBPP in Africa (Tulasne *et al*., 1996). The JP-16 concentrated more on different research aspects of CBPP rather than on a vaccination campaign (Atang, 1969). The successful approach links preventive vaccination of healthy cattle to the slaughter of sick animals in the event of an outbreak and/or revaccination of those at risk. The success of this method relies on the ability of the authorities to detect outbreaks rapidly, most effectively, by abattoir surveillance and to maintain vaccination coverage for at least three consecutive years (Provost, 1994).

Vaccination in endemic areas should be on an annual basis while newly-infected areas require more intensive programmes such as repeat vaccinations after 3, 9, 21 and 36 months aiming at eradication of the disease within this period (Egwu *et al*., 1996). Following the recommendations of the Ad Hoc Expert Group of the OIE in 1993 (OIE, 1993) guidelines were issued with the aim of eradicating CBPP initially from endemic regions and eventually worldwide. However, it is difficult to maintain the required intensity of vaccination due to costs and livestock movements. The most recent vaccination campaigns in Tanzania and Botswana have not provided the protection anticipated for reasons yet unknown (Egwu *et al*., 1996).

Vaccinating whole populations will gradually extinguish infection circulating in that population but only if a vaccination cover approaching 100% is achieved. Anything less means that there is the risk of susceptible (non-vaccinated) cattle contracting the disease. In such a situation the livestock owners and the authorities lose faith in the vaccination campaign and it fails (FAO, 1997a).

Control and monitoring of CBPP in Italy was primarily based on abattoir surveillance and the serological testing of cattle before movement. Both Italy and Portugal practice 'stamping out' of both affected and contact cattle; this policy has been effective as no outbreaks have been reported since September 1993 (Egwu *et al.*, 1996). A combination of cattle movement control, slaughter and vaccination were effective in eradicating CBPP from Australia (Provost *et al.*, 1987) and from Botswana (Raborogkwe, 1997).

Vaccines and vaccination

Today, CBPP vaccines are used only in Africa and parts of Asia including Assam. Vaccines are live preparations produced from one of two strains, KH_3J or T_1-44, each of which has a streptomycin variant, and are used in lyophilised form (OIE, 1994). It is generally accepted that they both provide insufficient immunity lasting less than one year and, more worryingly, that breakdowns can occur in vaccinated herds (Egwu *et al.*, 1996).

The KH_3J strain was probably isolated in the Juba region of Sudan and since then has been passaged 88 times in embryonated eggs. The vaccine does not cause any adverse reactions in cattle irrespective of route or volume of inocula; however, it confers poor immunity lasting only six months. It has been used widely in Western and Central Africa (Rweyemamu *et al.*, 1994).

The OIE recommended vaccine is the naturally mild T1-44 strain which has been passaged in eggs 44 times and was isolated in Tanzania some 40 years ago. It is sufficiently avirulent for zebu but can cause severe post-vaccinal reactions in *Bos taurus* breeds. However, some believe that the production of such lesions is essential for protective immunity (Hudson, 1971). The site of inoculation is crucial in order to achieve good immunity while limiting adverse effects. Windsor and Masiga (1977) showed that when animals were challenged by the in-contact method 15 months after primary vaccination, cattle vaccinated by either tail tip or the subcutaneous routes were solidly immune; whereas a quarter of cattle vaccinated by the intradermal route developed small sequestra in the lungs. Later, Garba *et al*. (1989) showed that cattle vaccinated with T1-44 by the tail-tip method produced higher antibody titres and gave better protection than cattle vaccinated by the neck route. Furthermore, contrary to accepted views on the superiority of live CBPP vaccines, these workers also showed that a formalised preparation made from the Australian Gladysdale strain gave better protection than T_1-44 or KH_3J (Garba *et al*., 1986,1989).

Vaccination entails the inoculation of all cattle above three months of age (DSE, 1980).
Despite the widespread use of vaccines in Africa, CBPP has persisted in many countries. In Nigeria, according to Osiyemi *et al*. (1985), this is attributable to the presence of concurrent disease such as trypanosomosis which is known to induce immunosuppression in vaccinated herds. Nonetheless there is a marked correlation between the annual doses of vaccine administered and control of CBPP in Nigeria (Nwanta and Umoh, 1992). Failure to maintain this effort because of economic and social reasons has led to an upsurge in cases.

Improper storage and handling of vaccines, and inadequate dosage can also be contributory factors in providing poor protection. Some of these factors may account for outbreaks seen in vaccinated herds in Tanzania during the last year although some believe that the combined CBPP/rinderpest vaccine is less effective than its monovalent counterpart (Mlengeya, 1995). Jeggo *et al*. (1987) had reported previously that the rinderpest virus component of the vaccine can interfere with the ability of the *Mmm*SC to induce an effective immune response.

The recent finding reported by Rweyemamu *et al*. (1994) that the streptomycin resistant T_1-44 (T_1-SR) vaccines may contain a mixed population of *M. mycoides* subspecies *mycoides* clones with different antigenic properties may help to explain why some batches of vaccine may be less effective than others, hence the withdrawal of the T1-SR vaccine seed strain (FAO, 1997c).

The minimum required dose of live CBPP vaccines is 10^7 organisms and is based on the work of Gilbert and Windsor (1971). They also showed that if the dose fell to 10^5 the cattle appeared more susceptible to CBPP than the controls. It is thus important to reach or exceed the minimum dose requirement. Consequently, it may be unwise to accept the suggestion of Rweyemamu *et al*. (1994) that $10^{6.5}$ may be a more practical passmark for vaccine potency. Plans are under way to develop Immunostimulating complex vaccines (Anon, 1995).

Chemotherapy in CBPP control

There is no doubt that the owners of infected animals sometimes treat them (FAO, 1997a). *MmmSC* is susceptible to a range of antibiotics including chloramphenicol, streptomycin and oxytetracycline (Turner, 1960). Tetracycline and erythromycin have also proved useful (FAO, 1967) and the usefulness of tylosin has been reported (Hudson and Etheridge, 1965). Recent studies on respiratory mycoplasmas indicate that enrofloxacin and lincomycin in particular, are mycoplasmocidal (Ball *et al*., 1995).

However, while chemotherapy to control vaccination reactions is not objectionable, chemotherapeutic treatment of actual cases of CBPP is discouraged in both Europe and Africa by the OIE (1995). This is because antibiotic treatment causes clinical signs that are often very mild thus, complicating clinical diagnosis (Bolske *et al*., 1995); furthermore treatment may not eliminate the causal agent especially in chronic cases where lesions are sequestrated (ter Laak, 1992). It is suspected that the recent outbreaks in Tanzania were exacerbated by the use of antibiotics which reduced the clinical signs while creating chronic carriers (Mlengeya, 1995). The FAO Expert Consultation on the Emergency Prevention System (EMPRES) in its conclusion (FAO, 1997a) indicated that treatment is only of value if cattle are in the incubation stage, i.e. when cattle are moving from infected areas to free areas (but only when the herd of origin is disease free), and in an outbreak where cattle are quarantined awaiting slaughter where the meat of survivors is of salvage value.

2.8 CBPP control policies and strategies in Kenya

Among the major epizootics in Kenya, CBPP is second to rinderpest in importance. The disease is reappearing in areas where it was previously controlled to such an extent that it is endemic in 50% of the country (FAO, 1996).

For the purpose of CBPP control there is a zonation of the country into different categories which is, however, under continuous revision; having been revised in 1975, 1982 and 1998 due to a changing disease situation (MOA, 1975, 1982, 1998).

There were three disease categories as from 1982 (see Annex 1a); category A included infected areas and areas of maximum risk such as Mandera, Wajir, Garissa, Lamu, Tanariver, Marsabit, Isiolo, Turkana, West Pokot, Bungoma, Busia and Siaya districts. In these districts all cattle were vaccinated annually against CBPP (Kane, 1975) and branded 'PN' to denote Rinderpest and CBPP vaccinations. For the purpose of slaughter only cattle bearing the latest recognised brand for category A areas were allowed to move. Cattle were only permitted to move to Kenya Meat Commission (KMC) factories in Athiriver or Mombasa and not to any other abattoir outside the category A areas except with permission of the Provincial Veterinary Officer (P.V.O) in consultation with the Director of Veterinary Services. Cattle were not allowed to move on hoof outside Category A areas. However, slaughter cattle that had passed 3 field CFT tests with a negative result in approved holding grounds (see Annex 2) were allowed to walk to a railhead through a recognised stock route. For fattening or breeding, only cattle bearing the latest recognised brand mark and which had passed three consecutive clear field CFT tests at six weekly intervals in isolation in an approved holding ground were allowed to move. All reactors were slaughtered and post mortem specimens submitted to the Central Veterinary Laboratory. Reactors included both positive and doubtful reactors.

Category B included areas of risk but not CBPP infected, and suspect areas. These were Samburu, Mukogodo division in Laikipia, Baringo, Kitui, Kilifi, Trans Nzoia and Kakamega districts. In these districts no vaccination was done. Slaughter stock were allowed to move to the railhead or the abattoir without testing or other restrictions as far as CBPP was concerned. Fattening or breeding cattle from these areas were allowed to move at the discretion of the P.V.O.

Category C included CBPP free areas i.e. the rest of the districts not in categories A or B. There were no CBPP control measures in these districts and no movement restrictions of any sort with respect to CBPP.

Recently in 1998, following yet more changes in the disease situation and for the purpose of CBPP eradication under the Pan African Control of Epizootics (PACE), the new suggested zonation of the country has resulted in three zones; I, II and III (see Annex 1b) has been suggested.

Zone I comprises the majority of the districts in Western and Central Kenya. This zone is considered CBPP free and no vaccinations against CBPP are carried out. Disease surveillance will be the major activity accompanied by zoo-sanitary measures at livestock markets, border check points (internal and external) and stock routes. Surveillance and reporting will be in place at all slaughterhouses with a trace back policy. Cattle from CBPP districts will only be allowed into this zone after passing three clear CFT tests.

Zone II includes the recently infected districts of Narok, Kajiado, Transmara, Naivasha and Gilgil divisions of Nakuru, Thika, Machakos, Makueni, Mwingi and Kitui. Based on disease surveillance and reporting, suspected outbreaks will be thoroughly investigated including traceback, and if an outbreak is confirmed, there will be mass screening and vaccination. All positive reactors will be slaughtered. Mass screening and vaccination will be repeated after six months. Zoo-sanitary measures as described for zone I will be enforced. After three years of intensive surveillance and vaccination, these areas may be declared free if no disease is found.

Zone III comprises the districts of Turkana, West pokot, Mandera, Wajir, Isiolo, Garissa, Tanariver, Lamu, Marsabit and Moyale (a new district curved out of Marsabit) and is regarded as endemic for CBPP. Intensive annual vaccination along with screening of cattle using mobile laboratories will be carried out. Zoo-sanitary measures at stock routes, stock markets and defined international entry points will be strenghthened as well as strict livestock movement control. Movement of cattle from these areas into clean areas will only be permitted on passing three clear CFT tests for CBPP at specified holding grounds. The status of CBPP in these areas will be evaluated at the end of 3 years and in collaboration with evidence of similar work being carried out in neighbouring countries as CBPP is one of the most important transboundary diseases. Vaccination in endemic districts is biannual using the freeze dried T1-44 vaccine at the foci and in in-contact herds (ring vaccinations).

For screening there are six established mobile laboratories, four of which are functional. The test used for screening is the field CFT. When the test was first developed four possible situations for its application were envisaged by Huddart (1963), i.e. eradication, screening, survey and quarantine testing. The value of the test in the eradication of CBPP within a herd is debatable, as, in order to remove all the infected animals, the test would need to be done at two day intervals to detect recently infected animals with developing lesions and antibody titres. This would require a large commitment of staff and equipment, and in fact, might encourage disease spread by mixing the cattle at the crush (Scudamore, 1975), observed during screening at holding grounds in Isiolo, Kenya.

In an attempt to strenghthen CBPP surveillance through meat inspection the veterinary department in Kenya has instructed the meat inspectors to record, report and submit lung samples with suspected lesions of CBPP to the nearest laboratory (MOA 1997).

In accordance with the recommendations of FAO (1967) and OIE (1995), the Kenya Veterinary Department discourages treatment against CBPP.

2.9 CBPP control under Panafrican programme for the control of epizootics (PACE)

The Pan-African Rinderpest Campaign (PARC) has been co-financed by the European Community (EC) since 1986. However, global elimination of rinderpest is so near that it requires only a final thrust; it would now be a major advantage to create an enabling environment for CBPP control in Africa by freeing resources to undertake the required strengthening (FAO, 1998). An OIE pathway for the eradication of CBPP similar to the one for rinderpest has been described (OIE,1993). PACE, a five year programme covering 32 sub-Saharan African countries and coordinated by the Inter-African Bureau for Animal Resources (IBAR) of the Organisation of African Unity (OAU), is to build on the headway made in the campaign against rinderpest in order to:

- Establish lower cost national and continental epidemiological surveillance networks for the main animal diseases;
- Provide the countries with the capacities needed to organise economically and technically justified control programmes;
- Develop effective and sustainable distribution of veterinary products and services.

The programme will include national operations planned and implemented in each country and also sub-regional and regional support and coordination components. Its most important outputs will be to remove one of the major constraints on the development of the livestock farming sector; disease and, thus, help to improve farmers incomes and peoples general living conditions (OAU/IBAR, 1999).

Besides suggesting a new zoning of the country for the purpose of CBPP control according to the current disease situation, Kenya has also described the guidelines to be used in CBPP control in the different zones in readiness for PACE (MOA, 1998).

3.0 MATERIALS AND METHODS

Field investigations were carried out in Kenya for a period of four months (January to April 1999) which involved passive and active data collection on CBPP outbreaks and cattle movement patterns, vaccination coverage from 1989 to 1998 and to map both outbreaks and vaccination coverage using georeferenced mapping systems and to determination of factors affecting CBPP reporting were also major objectives. The study was retrospective in nature covering ten years (1989-1998) with passive data and the last five years (1994-1998) also with active data.

3.1 Description of the study area

3.1.1 Areas for historical (passive) data collection

Passive data collection was carried out countrywide in Kenya. Kenya lies in the extreme East Coast of Africa with the following neighbours: Ethiopia and Sudan to the North, Somalia and the Indian Ocean to the East, Tanzania to the South and Uganda to the West. It lies between 34^0E and 42^0E and $5^0$30'N and $4^0$45'S. The country is divided into eight administrative provinces which are subdivided into a total of 68 districts. Moisture availability zones vary from humid to very arid labelled as zones 1-7 with average annual rainfall ranging from 2700 mm in Zone 1 to 150 mm in zone 7. There are nine temperature zones with mean annual temperatures ranging from less than 4^0C to less than 16^0C in the Afro-Alpine highlands (zone 1) and 24 to 36^0C in the lowlands (Zone 9) (Annexes 9a, 9b, 9c, 9d)

3.1.2 Areas for active data collection

To determine factors influencing disease reporting and to obtain additional information on outbreaks, vaccination and cattle movement patterns the study area included one district where the disease is believed to be endemic, 5 districts classified as newly infected and 2 districts considered to be under threat but still clean.

District where CBPP is endemic

These areas comprise the districts of Turkana, Westpokot, Mandera, Wajir, Isiolo, Garissa, Tana river, Lamu and Marsabit. The disease is endemic in these districts due to their location close to infected neighbouring countries (that is Ethiopia, Sudan and Somalia) and to the uncontrollable movement of cattle across the districts. However, the district included in this study is the Tana River district (Hola area). This district was chosen purposely because it is a district in which CBPP is the most important disease and transport costs for questionnaire administration were not prohibitive due to long distance as it would have been in the other endemic districts.

Districts classified as newly infected

By 1987 CBPP was only present north of the Tana river following stringent control measures in the 70s and early 80s. All slaughter animals from this area were slaughtered at the Kenya Meat Commission slaughterhouse. Following the closure of this slaughterhouse in 1987, the animals were channelled to other slaughterhouses in Nairobi which led to a surplus of slaughter animals grazing in Nairobi awaiting slaughter. Following civil disturbances in Somalia in 1991, refugees poured into Kenya and advanced with their animals as far as Nairobi in search of a market for their animals. These animals mixed with animals from the area referred to as "Maasailand" in southern Kenya, that is Kajiado and Narok, which often arrive in Nairobi in search of pastures, leading to the re-emergence of CBPP among these cattle. The situation was made worse by the purchase of the Somali animals by the Maasai to increase their herd sizes. Thus these districts, Kajiado and Narok were included in the study.

Following increased trade, land subdivision and droughts, pastoralists from CBPP endemic areas have moved, more than ever before, in search of pasture, water and markets. The emergence of CBPP in districts which include Nakuru, Thika, Machakos, Makueni, Mwingi and Kitui has then been observed.

The districts studied were Thika, Makueni and Mwingi. These districts were chosen because they are the most recently infected and have the unique features of being situated close to major trade routes. The Kenya Veterinary Department has also not been fully able to establish the source of the sporadic outbreaks experienced in these districts, hence outbreaks have continued.

Districts under threat

These are districts located close to the endemic areas or newly infected districts. The districts studied were Kiambu and Nairobi. These districts were chosen because they are the major final destination of slaughter cattle from endemic areas; there has been speculation that CBPP exists in the form of sporadic outbreaks very likely originating from slaughterhouses.

Thus, active data collection was carried out in eight districts which include Tana river in the Coast Province, Thika and Kiambu districts in Central Province, Mwingi and Makueni districts in Eastern Province, Narok and Kajiado district in Rift valley province and Nairobi district in Nairobi province (Annex 6). Geographical data of these districts are found in Annex 7.

3.2 Study protocol

3.2.1 Data collection

Data to describe and assess the disease outbreaks, cattle movements, vaccination coverage and disease reporting were collected passively using reports and actively using questionnaires.

3.2.1.1 Data for disease outbreaks compilations

Passive data covered 1989 to 1998 and active data 1994 to 1998.

District reports

Data from monthly and annual reports of all 68 districts of Kenya were collected and a summary of the recorded outbreaks per district was made. The actual number of cases involved in each CBPP outbreak is not possible to establish, as the Veterinary Department due to the nature of the disease expects reports of outbreaks rather than of individual cases from field veterinarians. However, outbreaks were defined as more than one case in endemic districts, and one or more cases in newly infected districts and in districts under threat from infected areas. The month of the yearr when the outbreaks occurred was recorded along with whether the outbreaks were confirmed or only suspected. Tests used to confirm the outbreaks and traceback of outbreaks was also recorded along with whether quarantine was imposed and for how long.

Slaughterhouse reports

Twelve slaughterhouses were visited: Two each in Kajiado and Mwingi, one each in Tanariver, Thika, and Makueni. Since most cattle for slaughter are traded in Nairobi and Kiambu districts as live animals from allover the country (including from areas in which CBPP is endemic), visits were made to all major slaughter houses in Nairobi and in Kiambu i.e. Nyonjoro, Dandora, Kayole, the private Hurlingham slaughterhouse in Nairobi and Dagoretti complex in Kiambu. Data concerning movement of cattle into the slaughterhouse such as records of movement permits, with origin of cattle, date of issue of permits, date of arrival of cattle, number of cattle in permits and number of cattle delivered including mode of transport were collected on a yearly record basis from 1991 to 1998 from the Dagoretti slaughter complex being the only one with a comprehensive record of movement permits. No data on actual CBPP cases were available from any of the slaughterhouses as only the conditions (e.g. pneumonia) but not diagnosis was recorded. The records for 1989, 1990 and 1996 were missing. Slaughterhouse classification data were collected from the meat hygiene section of the Kenya Veterinary Department.

Laboratory reports

Sera and post-mortem samples from suspected cases from the field and slaughterhouses were normally sent to the Central Veterinary Laboratory (CVL) in Kabete. Data were collected on a yearly record basis from the serology section of the CVL Kabete and included for sera the laboratory CFT result based on the technique developed by Campbell and Turner (1953) and for postmortem samples of lung, trachea or lymph nodes AGID results based on the technique by Griffin (1965).

Mobile laboratory reports

Reports of Kenya's mobile laboratories and screening units which use the field CFT, as described by Huddart (1963), upon which positive animals are slaughtered were collected to provide data on screening results in case of movement and in case of an outbreak. Data were recorded per district. To determine the proportion of cattle moved that were screened, the number of cattle moved and that screened in endemic areas were recorded.

3.2.2 Questionnaires

In the study area, standardised questionnaires were administered to obtain additional information not to be found in the reports, and also to gain a better picture of the occurrence and seasonality, if any, of the disease to be linked to cattle movement patterns. The questionnaires were also used to collect data such as whether the farmers and veterinary staff are familiar with the disease, the factors influencing disease reporting, whether there is evidence of rumors, action taken on outbreaks and rumours by farmers, veterinary personnel and other field staff. Furthermore, the questionnaires were also used in determining the economic implications of CBPP mortality. Questionnaires were pretested on two persons per questionnaire to ensure that the final questionnaires were free of the common questionnaire problems such as ambiguity, questionnaire being too long and that the questionnaire conforms to standard questionnaire construction as described by Gardner (1976).

Four different types of questionnaires were administered directly by the investigator, aided by local field staff on particular questions requiring a better understanding by either the interviewee or the investigator, to:

1. the farmer, the spouse, a member of the family, the herdsman or the farm manager depending on who was available, but mainly to the person who was in best contact with the animals (see Annex 8a).

2. the veterinarian in charge of the specific area such as the district veterinary officer or the divisional veterinary officer, and the private veterinarians. One veterinarian each from

Makueni, Thika, Tana river, and Mwingi district, two veterinarians each from Kajiado, Kiambu, and Narok districts and four in Nairobi districts were interviewed (see Annex 8b).

3. the veterinarian or paraveterinary personnel in charge of the slaughterhouse. Twelve questionnaires were administered; one each in Thika municipality, Thika district, Wote in Makueni district, Hola in Tana river district, Bisil and Kitengela in Kajiado district, Migwani and Mwingi town in Mwingi district, Dagoretti in Kiambu district and Hurlingham, Nyonjoro, Kayole and Dandora in Nairobi district (see Annex 8 c).

4. the paraveterinary staff such as Animal Health Assistants (AHAs) and Junior Animal Health Assistants (JAHAs) leading to one staff each in Tana river and Narok, two each in Makueni, Thika, Kiambu, and Kajiado, three in Nairobi and five in Mwingi (Annex 8d).

3.2.2.1 Sampling strategy for questionnaire administration

As the aim of this study was to gather as much relevant information as possible from as many different farmers, the number of farmers to be interviewed was determined by the time limit (Schloete, personal communication). Farmers to be interviewed were arbitrarily selected from a list provided by the field veterinary personnel.

The sample size for veterinary, paraveterinary and slaughterhouse personnel to be interviewed depended on the availability of the staff; however, it was attempted to interview at least one per category and district.

3.2.2.2 Determination of vaccination coverage

CBPP in Kenya is a state controlled disease and any vaccinations carried out must be approved by the Chief Veterinary Field Officer (CVFO). Thus, official figures for vaccine distributed were obtained from the Veterinary Department's vaccine store at the CVL Kabete where a records of the vaccine distribution to the different districts are kept. Yearly vaccination figures were obtained from the district annual reports. Yearly cattle population estimates were obtained from the Kenya Animal Production Department of the Ministry of Agriculture. To describe and compare the monthly vaccination practice for districts practicing vaccination as a control method, vaccination data was collected per district per month for the 10 year study period. It was not possible to collect data for every district for all the 10 years because of time limitations.

3.2.2.3 Determination of cattle movement patterns

Cattle movement patterns were established through interviews with field veterinary staff, with farmers either individually or communally at market places and/or watering points, and from monthly and annual veterinary departmental reports. The existing maps on official cattle movement routes were updated through interviews with the CVFO and staff from the Pan African Rinderpest Campaign Kenya (PARC-K) who had recently (1998) worked on cattle movement patterns.

3.2.2.4 Georeferenced mapping of CBPP and vaccination coverage in Kenya

Paper maps to depict the coordinates of outbreak locations were obtained from Kenya's Department of Resource Surveys and Remote Sensing (DRSRS). The maps used were Universal Transverse Mercator (UTM) of the scales 1: 50,000, 1: 250,000 and 1: 1,000,000. The coordinates were obtained by measuring out the length in centimetres of one degree longitude and latitude. The location of the outbreak was determined as a fraction (in decimal with two decimal places) of one degree in relation to the nearest longitude and latitude. Longitudes to the East are positive and those to the West are negative while latitudes to the North are positive and those to the South are negative.

3.2.3 Data analysis

3.2.3.1 Summary of disease outbreaks

Disease outbreaks were summarised and tabulated by year, district and zone and described as either confirmed or suspected. Linear time series analysis was applied to assess trends of confirmed and suspected disease outbreaks using Microsoft Excel 97 (Microsoft Corp.). All graphs, unless otherwise stated, were constructed in MS Excel 97. Outbreaks were further broken down for the wet and dry season in form of a barchart; trends are demonstrated as trendline graphs. Trace back of outbreaks were described for the risk factors purchase from CBPP districts, illegal cattle movement for trade and grazing, movement from slaughterhouses, purchase from other markets, infected neighbour and transboundary migration. The tests used for the confirmation of outbreaks were summarised in the form of a pie chart and the results of the laboratory CFT and AGID were tabulated and a line graph for sample submission constructed. Screening results per district in the event of an outbreak using the field CFT were demonstrated using the box and whisker plot technique in Statgraphics Plus 2.1 (Manguistics, Inc., Rockville, Ma., USA). The proportion of cattle and the screening results were tabulated and summarised in the form of a line graph.

3.2.3.2 Cattle movement

The movement patterns were drawn by hand on A4 size current maps of Kenya and scanned using a HP Scanjet IIC. The scanned maps were registered to reference latitude/ longitude followed by on screen digitising. Maps demonstrating transhumance, trade routes and cattle rustling were thus produced using the GIS software MapInfo Professional 4.5; An overlay of the maps produced the summarised cattle movement patterns. The origin of cattle moved for slaughter countrywide and to the Dagoretti slaughter complex in particular was tabulated and summarised in the form of piecharts. The mode of transport of cattle of known and unknown origin to Dagoretti complex was presented in the form of a line graph.

The correlation of cattle indicated in permits and cattle actually arriving at the Dagoretti complex was demonstrated graphically by plotting the former against the latter using regression analysis in Statgraphics Plus 2.1 and the unexplained variation of head of cattle in permits from head of cattle delivered to Dagoretti complex was demonstrated by a line graph.

The variation in days in transit of cattle moving to Dagoretti complex was demonstrated in the form of a box and whisker plot using Statgraphics Plus 2.1. An overlay of the disease outbreaks summary map and the cattle movement patterns summary map displaying the relationship of between outbreaks and movement was prepared in Arcview 3.0a.

3.2.3.3 Vaccination coverage

The vaccination coverage was calculated on an yearly basis per district as follows:

$$\frac{\text{No. of vaccine doses used in that year in that district} \times 100}{\text{District cattle population estimate in that year.}}$$

and displayed graphically. Using box and whisker plots the vaccination coverage between years and between districts from 1989-1998 was demonstrated.

The unexplained variation between vaccine distributed and actual use in Kenya for the study time interval, the effect of vaccination on outbreaks in CBPP endemic and in Narok district (newly infected) as well as the monthly vaccination practice for all vaccinating districts were presented as line graphs. Vaccination coverage was compared between years and between districts using Kruskal Wallis test.

3.2.3.4 Georeferenced mapping of CBPP and vaccinations against CBPP

To map CBPP, the coordinates of locations of outbreaks, stored in Microsoft Excel format and then imported into Microsoft Access, were added to a vector digitised map of Kenya in ArcInfo E-00 format which was converted to MapInfo tab format. The results were presented as thematic maps of CBPP in Kenya from 1989 to 1998. Different colour codes were used for suspected outbreaks and for confirmed outbreaks.

The outbreaks were also summarised in a single map. The overlay of the CBPP zonation map from 1982 and the outbreaks summary map produced was used to substantiate further the suggested new zones of CBPP.

To map CBPP vaccinations, the data on vaccination coverage in Microsoft Excel format were imported into Microsoft Access. The vaccination data was added to the digitised map in Mapinfo format by linking the map with the attribute table of vaccinations. The results were presented as thematic maps of CBPP vaccination coverage from 1989 to 1998. Different colour codes were used for different vaccination coverage ranges. As it was difficult to attach labels to the different districts due to their small size and overcrowding of the thematic maps, a separate map of Kenya districts was produced for use with all georeferenced information in this study Annexes 9a and 9b).

3.2.2.5 Determination of the factors affecting disease reporting

To describe the factors affecting disease reporting by farmers and to come up with other information on CBPP, the questionnaire data were analysed using Microsoft Excel 97.

Farmer questionnaire

- Disease ranking. The farmers were asked for the first five most important diseases and a score was awarded for the diseases. The total score was used to rank the disease.
- The loses per farmer per year were calculated for each study district.

$$\text{Losses per farmer} = \frac{\text{Total losses}}{\text{Number of farmers interviewed} \times 5^{*}}$$

* = No. of years covered by the questionnaire

The total losses per district were calculated

$$\text{Total losses per district} = \frac{\text{Total losses}}{\text{Total herd size among interviewed farmers in district}} \times \text{Average cattle estimate in district for the last 5 years}$$

The recovery rate was determined by taking the number of cattle recovering out of 10 and then,

$$\text{Recovery rate} = \frac{\text{No. of cattle recovering}}{10} \times 100$$

Household data, local terms for CBPP, history of CBPP and age groups affected, vaccination, reports of rumours, personnel to whom disease is reported, action taken by the farmer and by the veterinary personnel and the clinical signs and post mortem lesions of CBPP reported by farmers were summarised in tables.

Slaughterhouse questionnaires

A description was given on movement of cattle to slaughterhouses, presence of holding grounds, antemortem inspection and meat inspection and action taken when CBPP cases were encountered. The opinion of slaughter house personnel on the role of slaughterhouses and the classification of slaughterhouses was described.

4.0 RESULTS

The study was carried out to summarise CBPP outbreaks and relate them to cattle movement. Furthermore, vaccination coverage and its effect on outbreaks as well as factors affecting disease reporting by farmers had been assessed.

4.1 Summary of outbreaks

Confirmed and suspected outbreaks are summarized in tables 1, 2 and 3 and in Figure 1.

Table 1: Summary of confirmed and suspected CBPP outbreaks by year in Kenya 1989-1998

Year	Confirmed	Suspected
1989	16	0
1990	18	3
1991	30	4
1992	15	2
1993	20	4
1994	19	8
1995	12	4
1996	11	2
1997	9	1
1998	6	7
Total	156	35

Table 2: Summary of confirmed and suspected (in brackets) CBPP outbreaks by district, Kenya, 1989-1998

District Classification	District	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Total
Endemic	Garissa	1	0(1)	0	0	0	3	3	4	1	0	12(1)
	Lamu	1	1	1	0	0	1	0	0	0	0	4
	Turkana	1	0	4	0	2	1	0	3	1	0	12
	Mandera	0	0	0(1)	0	0(1)	0(1)	0	0	0	0	0(3)
	Tana River	0	0	2	0	0(1)	0	0	0	0	0	2(1)
	Marsabit	0	0	0	0(1)	0	0(1)	0	0	0(1)	0	0(3)
	Westpokot	0	0	0	0(1)	0	0	0	0	0	0(1)	0(2)
	Isiolo	0	0	0	0	1	0	0	1	0	0	4
	Wajir	0	0	0	0	0	0(1)	0(1)	0(1)	0	0(3)	0(6)
SUBTOTAL		3	1(1)	7(1)	0(2)	3(2)	5(3)	3(1)	8(1)	2(1)	0(4)	32(16)
Newly infected	Kitui	1	1	0(1)	0	0	0(1)	0	0(1)	0	0	2(3)
	Machakos	4	0	1	3	0	5	1	0	2	0	16
	Mwingi	0	0	0	0	0	0	0	0	1	0	1(1)
	Nakuru	1	0	2	1	0	0	1	1	0	0	6
	Narok	1	9(1)	8	1	9(2)	0(3)	4(1)	1	1	3(1)	37(8)
	Kajiado	0	0(1)	1(1)	1	2	1	1(2)	0	0	1(1)	7(5)
	Thika	0	0	0	0	0	0	0	0	1	2	3
	Makueni	0	0	0	0	0	1(1)	0	0	0	0	1(1)
	Transmara	0	0	0	0	0	3	1	1	0	0	5
SUBTOTAL		7	10(2)	12(2)	6	11(2)	10(5)	8(3)	3(1)	5	6(2)	78(18)
Clean	Embu	2	0	0	0	2	0	0	0	0	0	4
	Kilifi	2	2	5	5	1	0	0	0	1	0	16
	Kirinyaga	1	0	0	0	0	0	0	0	0	0	1
	Meru	1	0	0	0	0	0	0	0	0	0	1
	Kiambu	0	2	2	1	0	0	0	0	0	0	5
	Laikipia	0	0	1	1	1	2	0	0	0	0	5
	Samburu	0	3	0	0	0	2	1	0	0	0	6
	Taitataveta	0	0	2	0	0	0	0	0	0	0(1)	2(1)
	Mombasa	0	0	1	1	1	0	0	0	0	0	3
	Nairobi	0	0	0(1)	1	0	0	0	0	0	0	(1)
	Nyandarua	0	0	0	0	1	0	0	0	0	0	1
	Bungoma	0	0	0	0	0	0	0	0	0	1	1
SUBTOTAL		6	7	10(1)	8	5	2	1	0	1	1(1)	46(2)
TOTAL		16	18(3)	30(4)	15(2)	20(4)	19(8)	12(4)	11(2)	9(1)	6(7)	156(35)

Table 3: Summary of confirmed and suspected CBPP outbreaks by zone, Kenya, 1989-1998.

Zone	Outbreaks	Suspects	Total
1. Clean	46	1	47
2. Newly infected	78	18	96
3. Endemic	32	16	48
Total	156	35	191

Outbreaks were experienced in all zones with the highest numbers in newly infected districts.

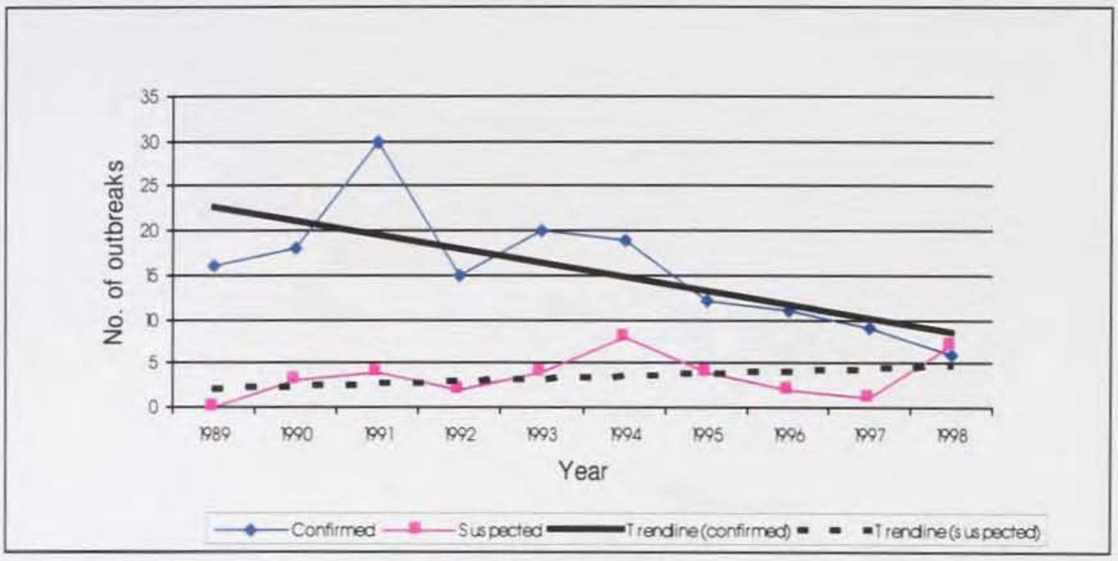


Figure 1: CBPP confirmed and suspected outbreaks, Kenya, 1989-1998

While outbreaks over the years investigated were on the decrease, suspected outbreaks varied between 1 and 6 (Fig.1).

Georeferenced maps of CBPP confirmed and suspected outbreaks in Kenya from 1989 to 1998 are demonstrated in Figures 2 to 11 and outbreaks are listed in Annex 21.

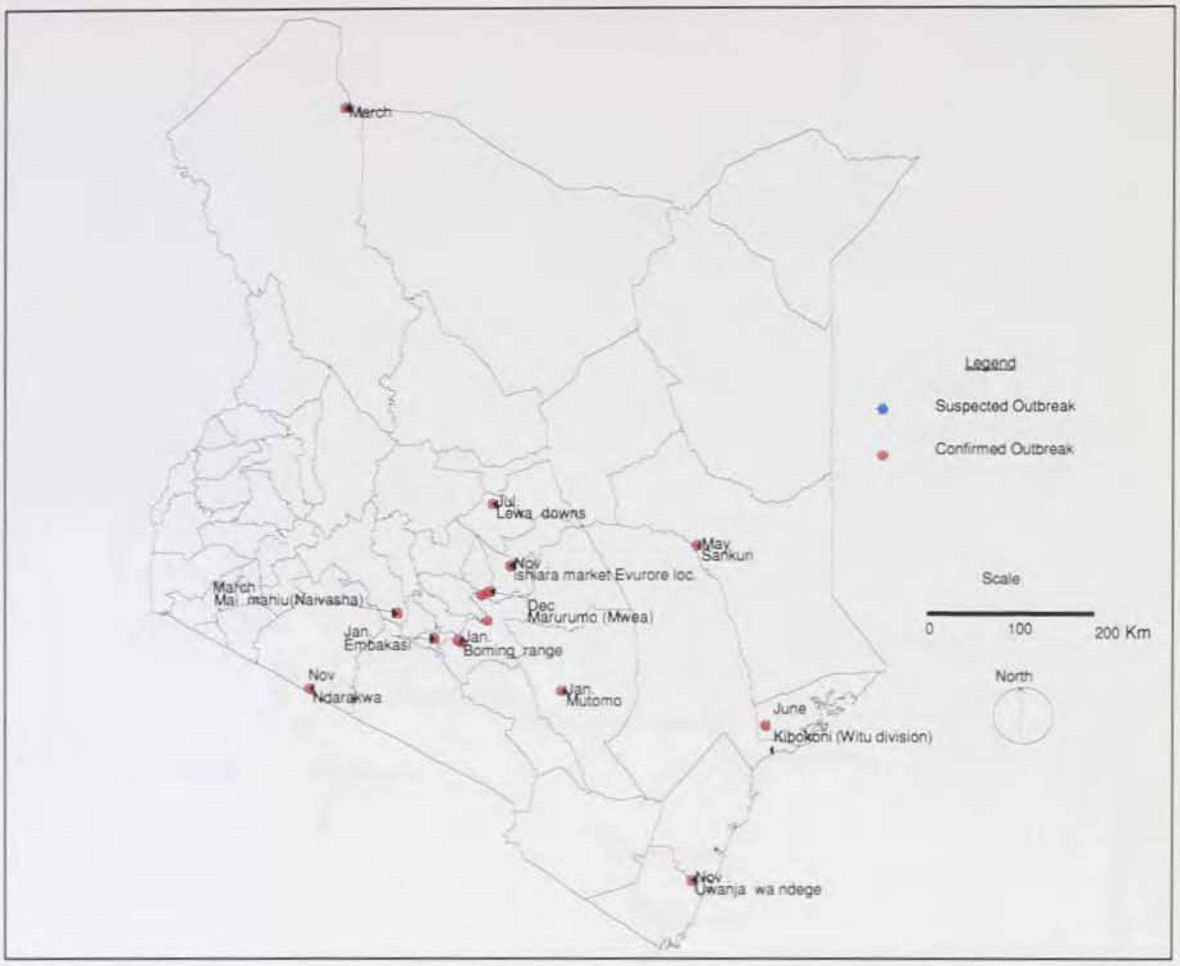


Figure 2: Map of CBPP outbreaks in Kenya in 1989

In 1989 CBPP outbreaks concentrated in Nairobi and the districts along the stock route for cattle en-route to Nairobi from the North, that is in Meru, Embu and Kirinyaga. Outbreaks were also observed in the Ukambani districts of Machakos and Kitui and also in Garissa, Lamu and Turkana. Outbreaks appeared for the first time in twenty years in Nakuru and Narok districts (Fig. 2).

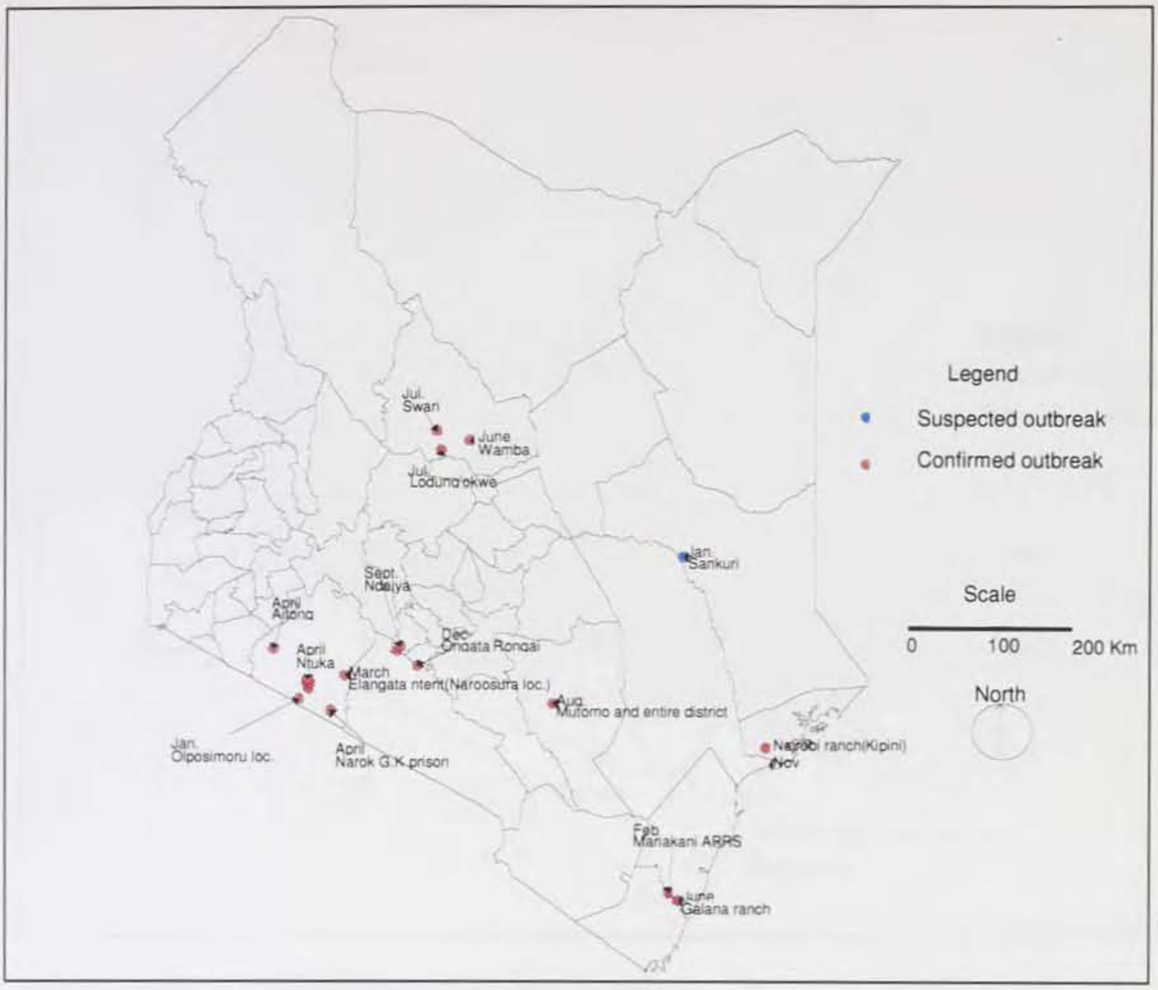


Figure 3: Map of CBPP outbreaks in Kenya in 1990

In 1990 the number of outbreaks increased in Narok district and appeared first in Samburu district, however, continuing in Kilifi, Lamu, Kitui and Garissa. Outbreaks were also experienced in Kiambu district and in Ongata Rongai in Kajiado district (Fig. 3).

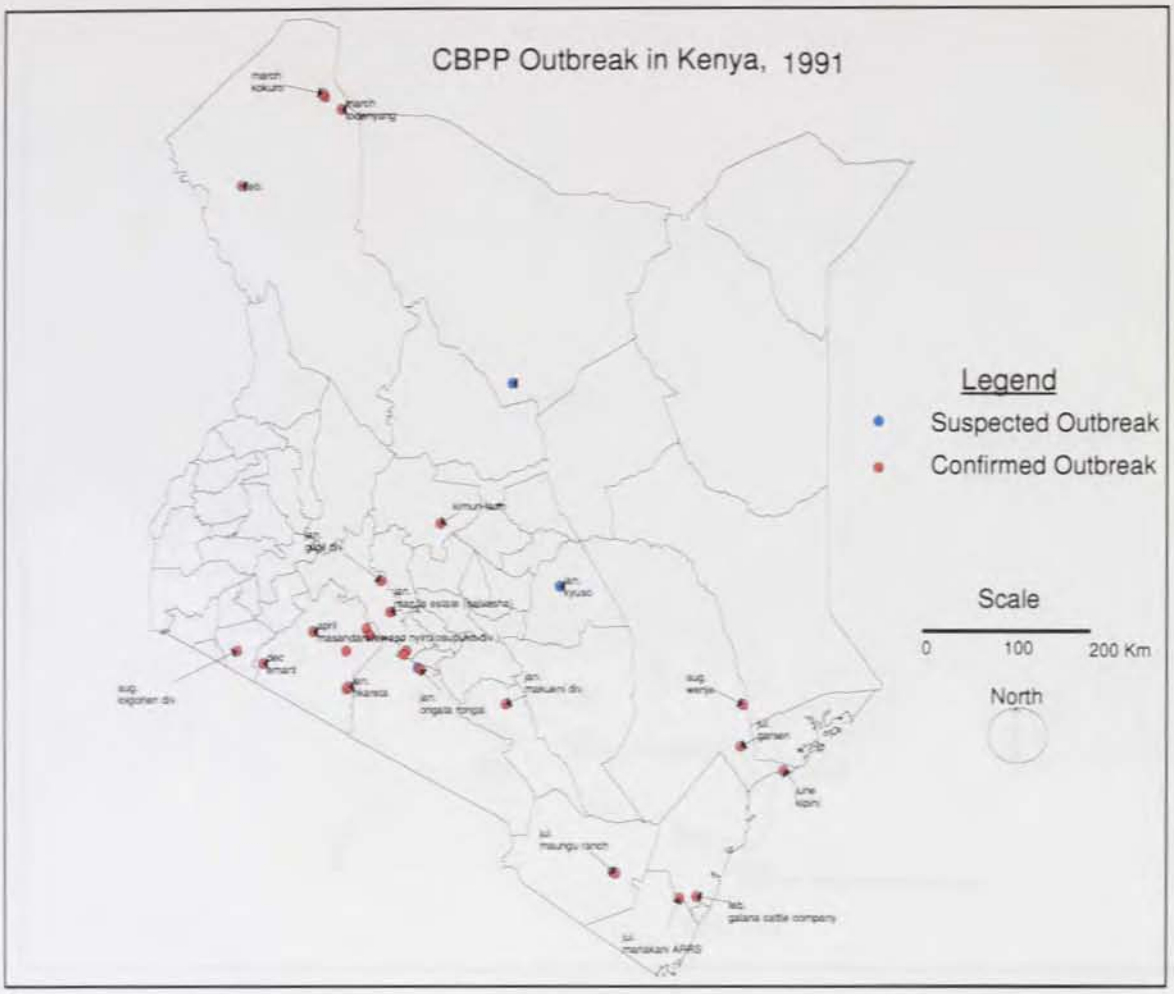


Figure 4: Map of CBPP outbreaks in Kenya in 1991

In 1991 outbreak events in Narok district moved northwards and into Nakuru district. The disease also spread to Tana River district and Taita Taveta in the Coast Province and continued in Kilifi and Lamu. Outbreaks were also recorded in Kajiado, Kiambu, Laikipia, Turkana and Makueni. Suspected outbreaks occurred in Mwingi and Marsabit districts (Fig. 4).

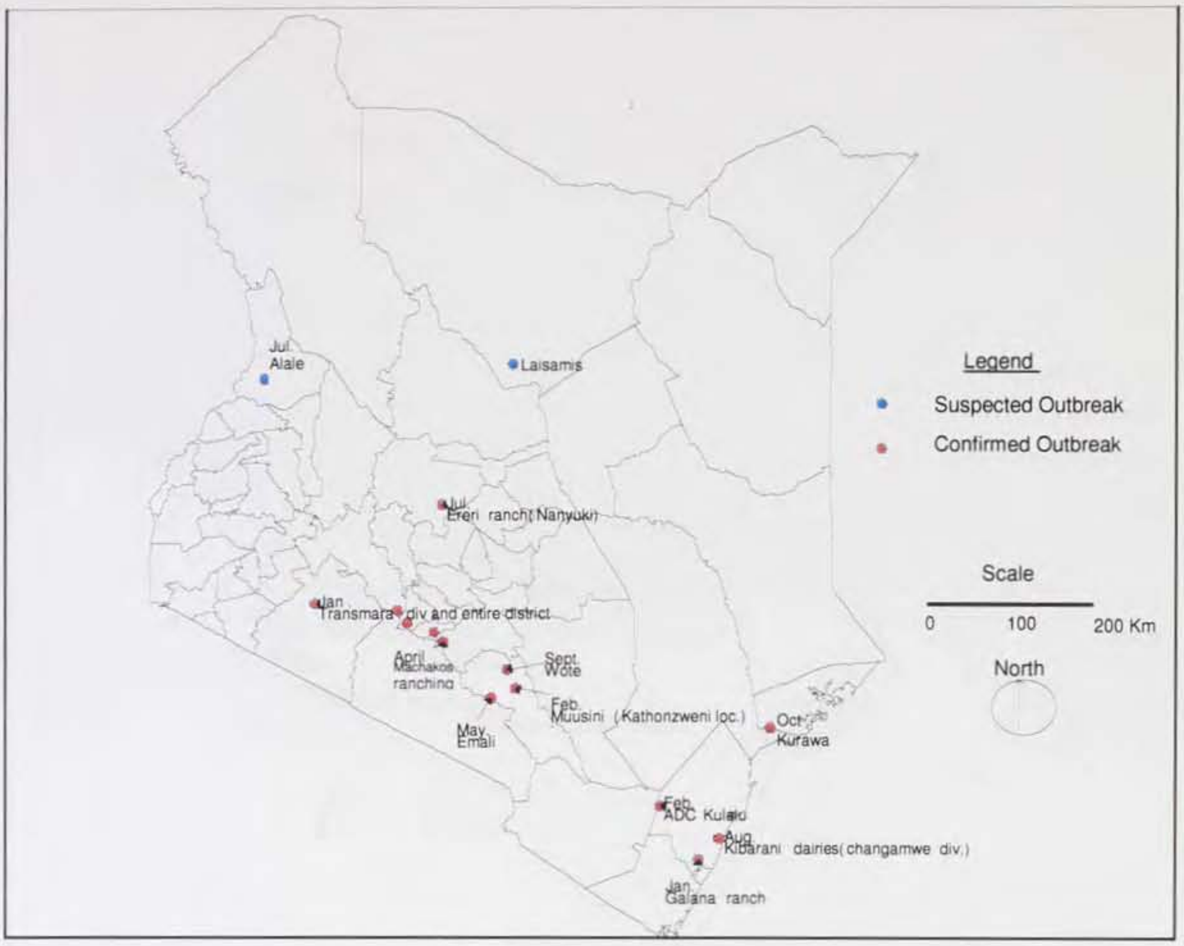


Figure 5: Map of CBPP outbreaks in Kenya in 1992

In 1992 outbreaks continued in Kilifi, Nairobi, Kiambu, Nakuru, Laikipia and Kajiado district. While outbreaks declined in Narok district, they increased in Makueni district. Only suspected outbreaks were recorded in Marsabit and West pokot districts (Fig.5).

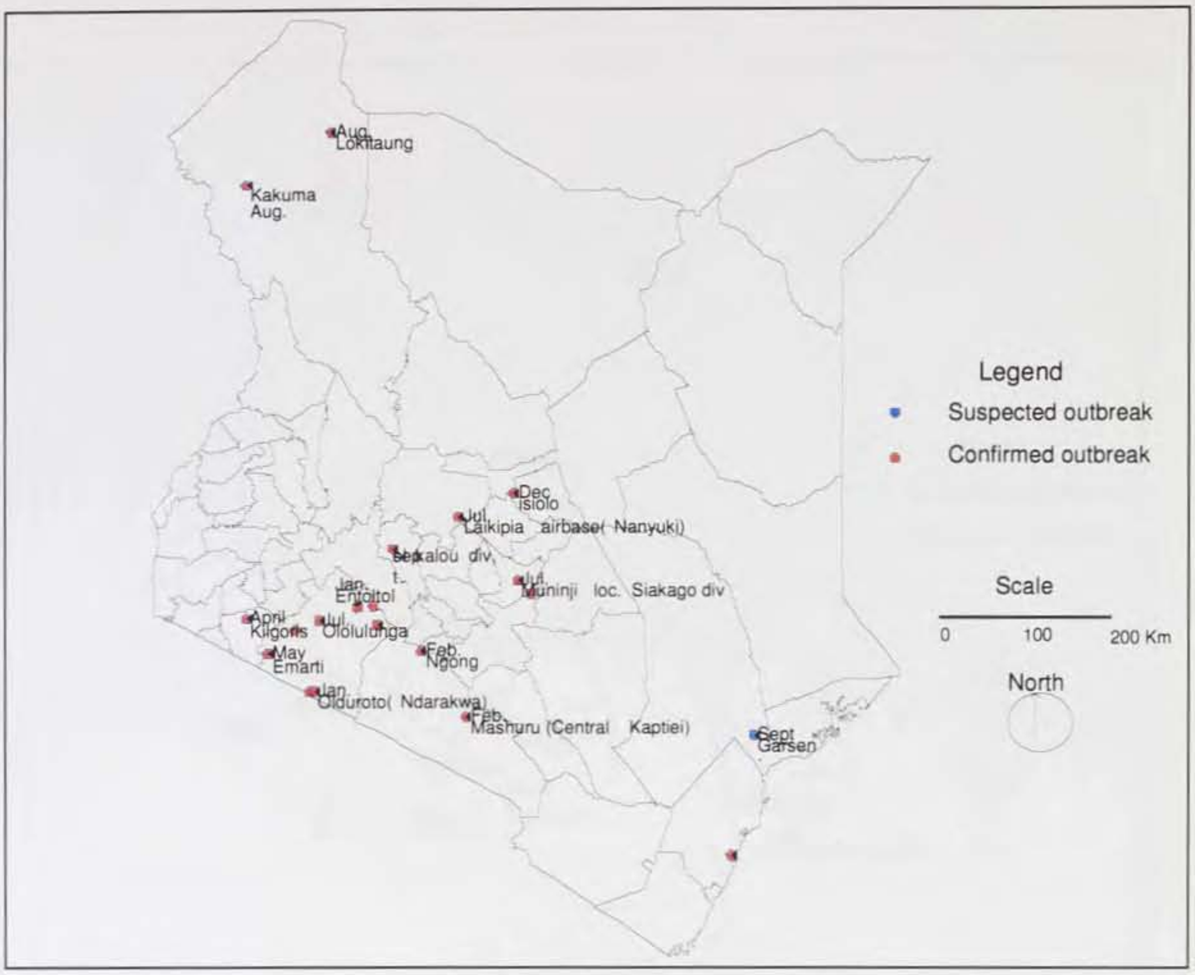


Figure 6: Map of CBPP outbreaks in Kenya in 1993.

In 1993 outbreaks multiplied in Narok district spreading further into Trans Mara district and Kajiado. While declining in Kilifi district outbreaks continued in Laikipia. New outbreaks were experienced in Turkana, Isiolo, Nyandarua and Embu districts. A suspected outbreak was recorded in Tana River district (Fig. 6).

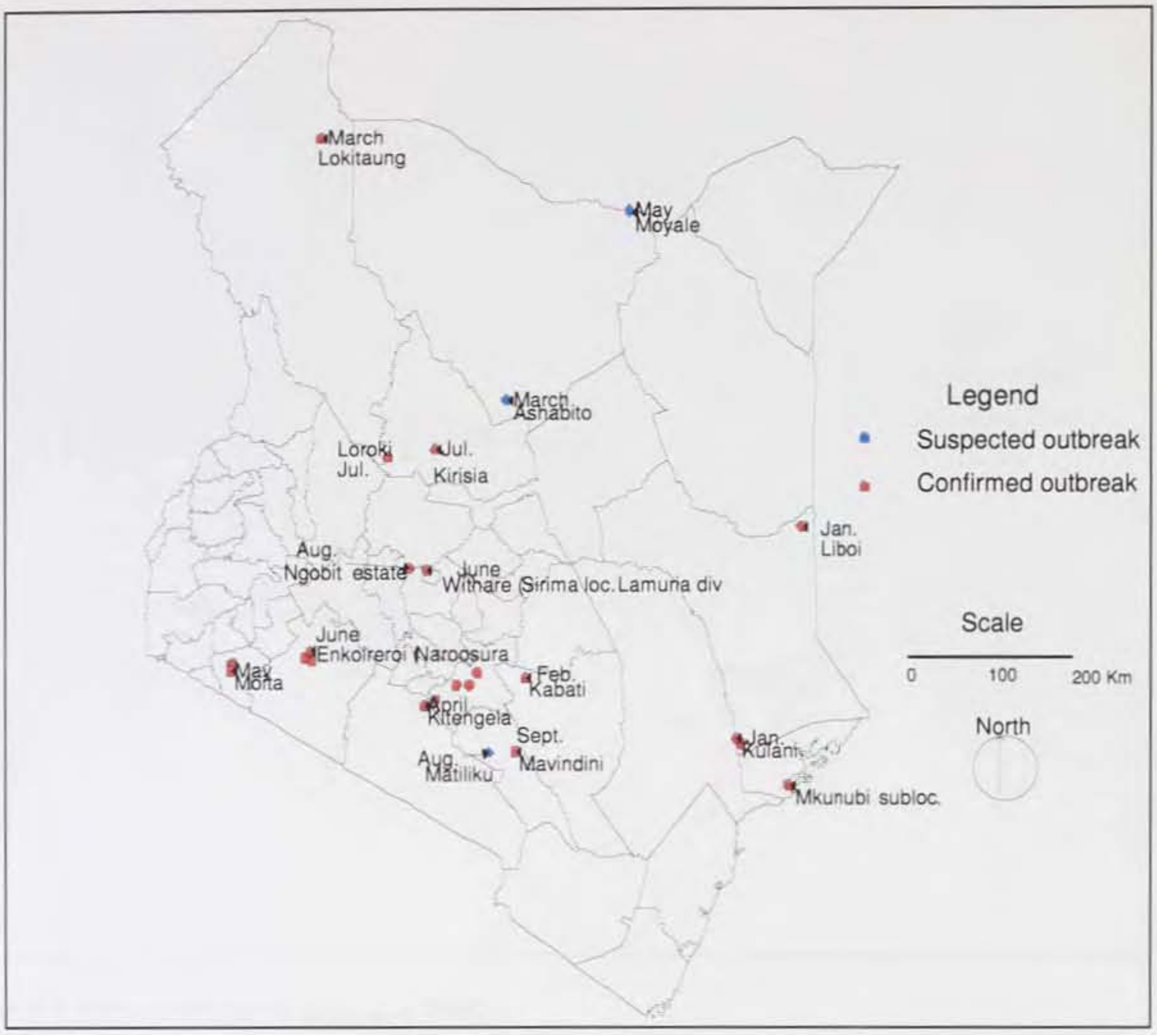


Figure 7: Map of CBPP outbreaks in Kenya in 1994

In 1994 outbreaks decreased in Narok district but concentrated in Machakos, Trans Mara, Laikipia and Turkana and Kajiado. New outbreaks were recorded in Lamu, Garissa, Makueni, and Samburu districts. Suspected outbreaks were recorded in Marsabit district (Fig. 7).

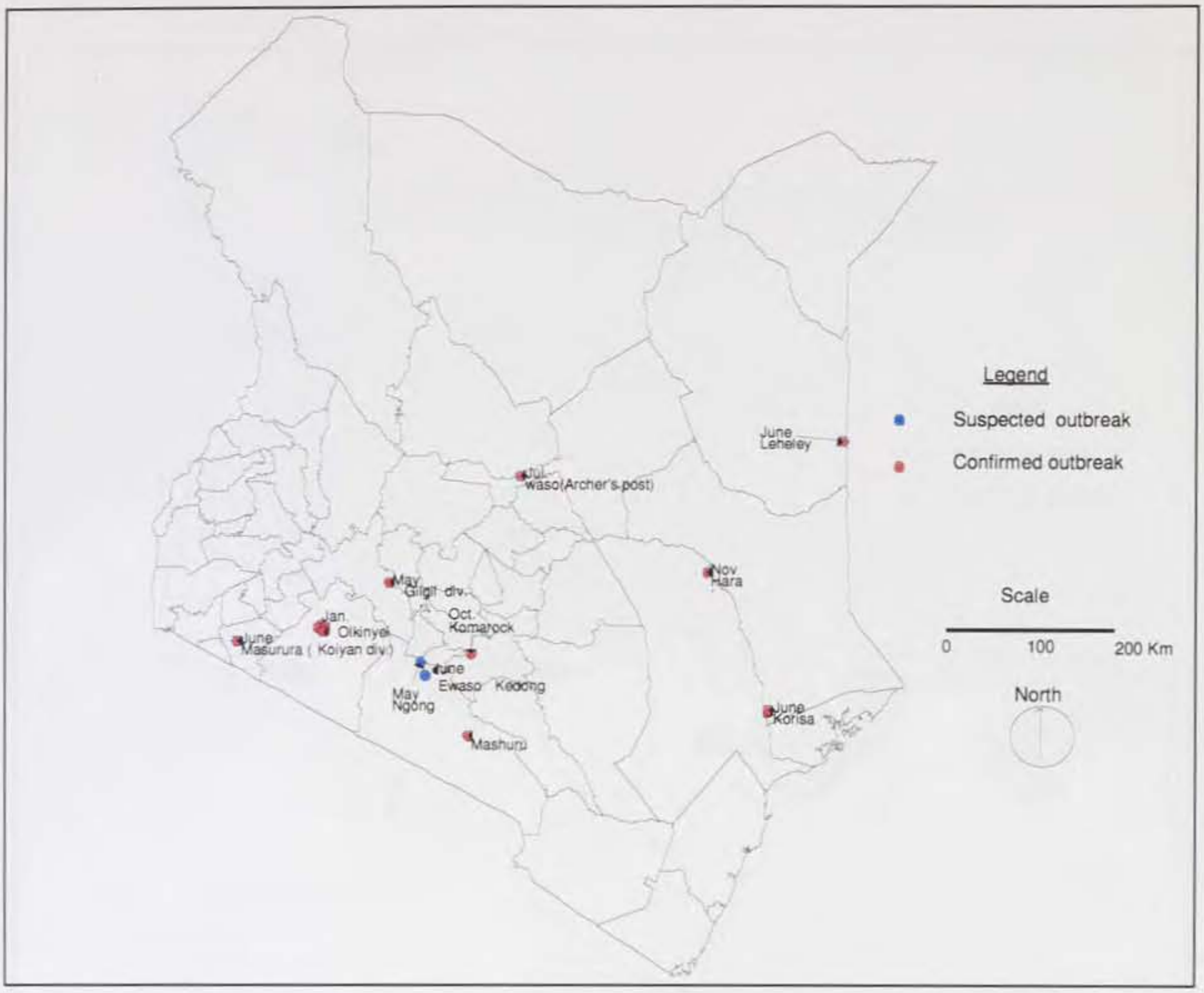


Figure 8: CBPP outbreaks in Kenya in 1995.

In 1995 outbreaks continued in Narok, Transmara, Garissa and Kajiado district. While the disease declined in Machakos and Samburu, new outbreaks were recorded in Tanariver, Nakuru and Wajir districts. Two suspected outbreaks were recorded in Kajiado district (Fig. 8).

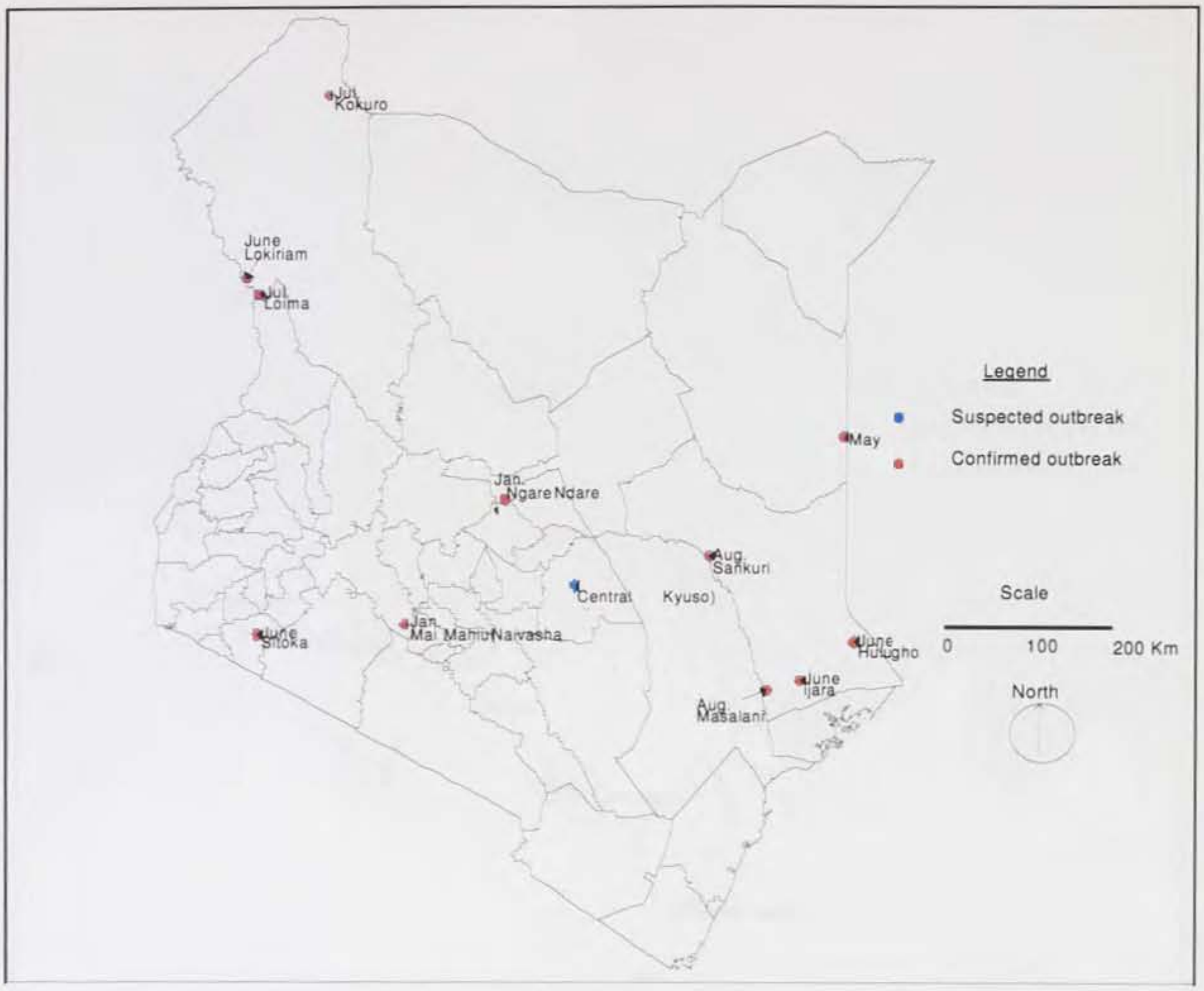


Figure 9: Map of CBPP outbreaks in Kenya in 1996

In 1996, new outbreaks were recorded in Turkana district and Isiolo while outbreaks continued in Wajir, Trans Mara and Nakuru; also the disease spread further into Garissa district. Suspected outbreaks were recorded in Mwingi district (Fig. 9).

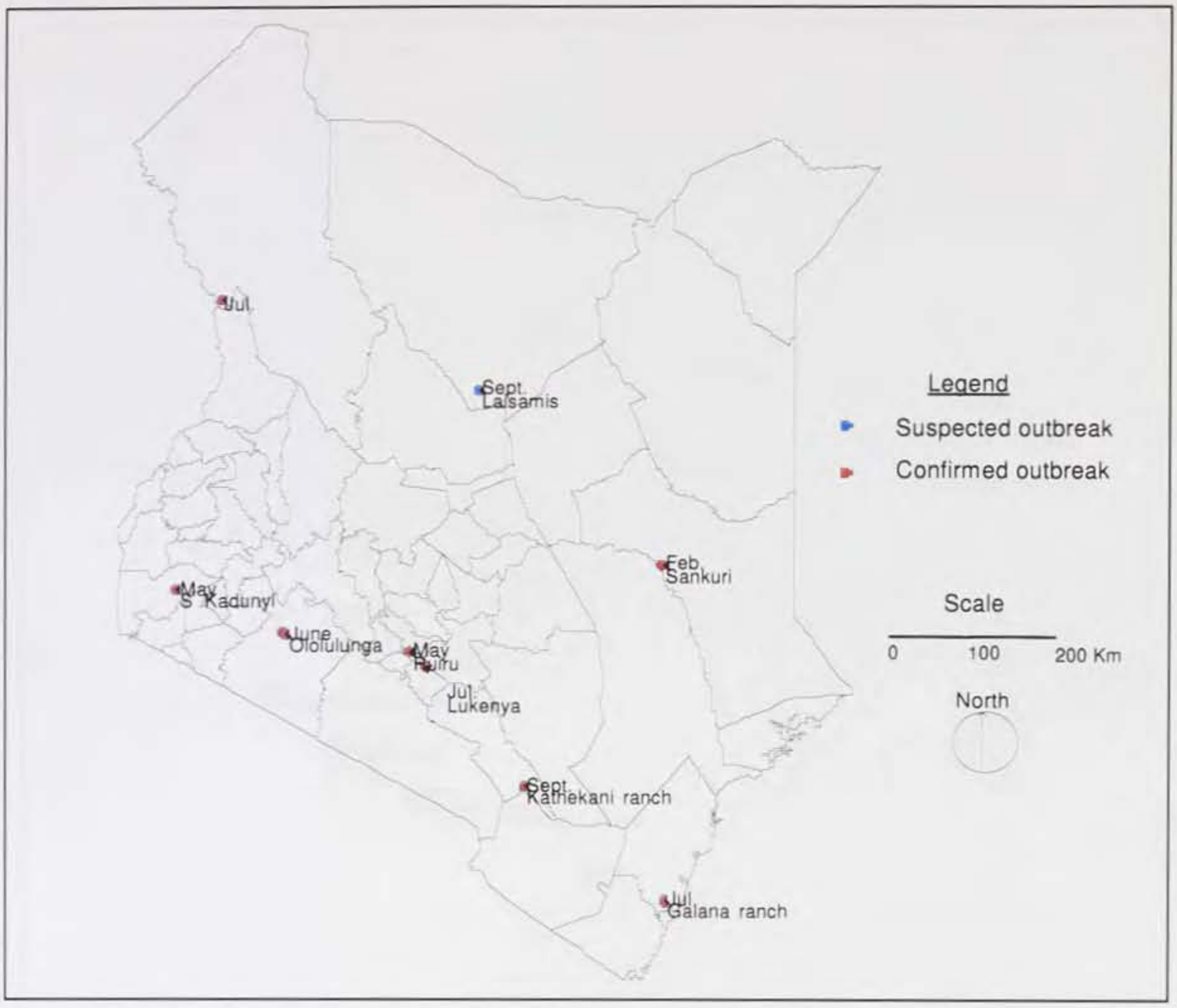


Figure 10: Map of CBPP outbreaks in Kenya in 1997

In 1997 new outbreaks were recorded in Kilifi, Makueni, Narok, Bungoma and Thika district. Outbreaks however declined in Garissa and Turkana districts while a suspected outbreak was recorded in Marsabit (Fig. 10).

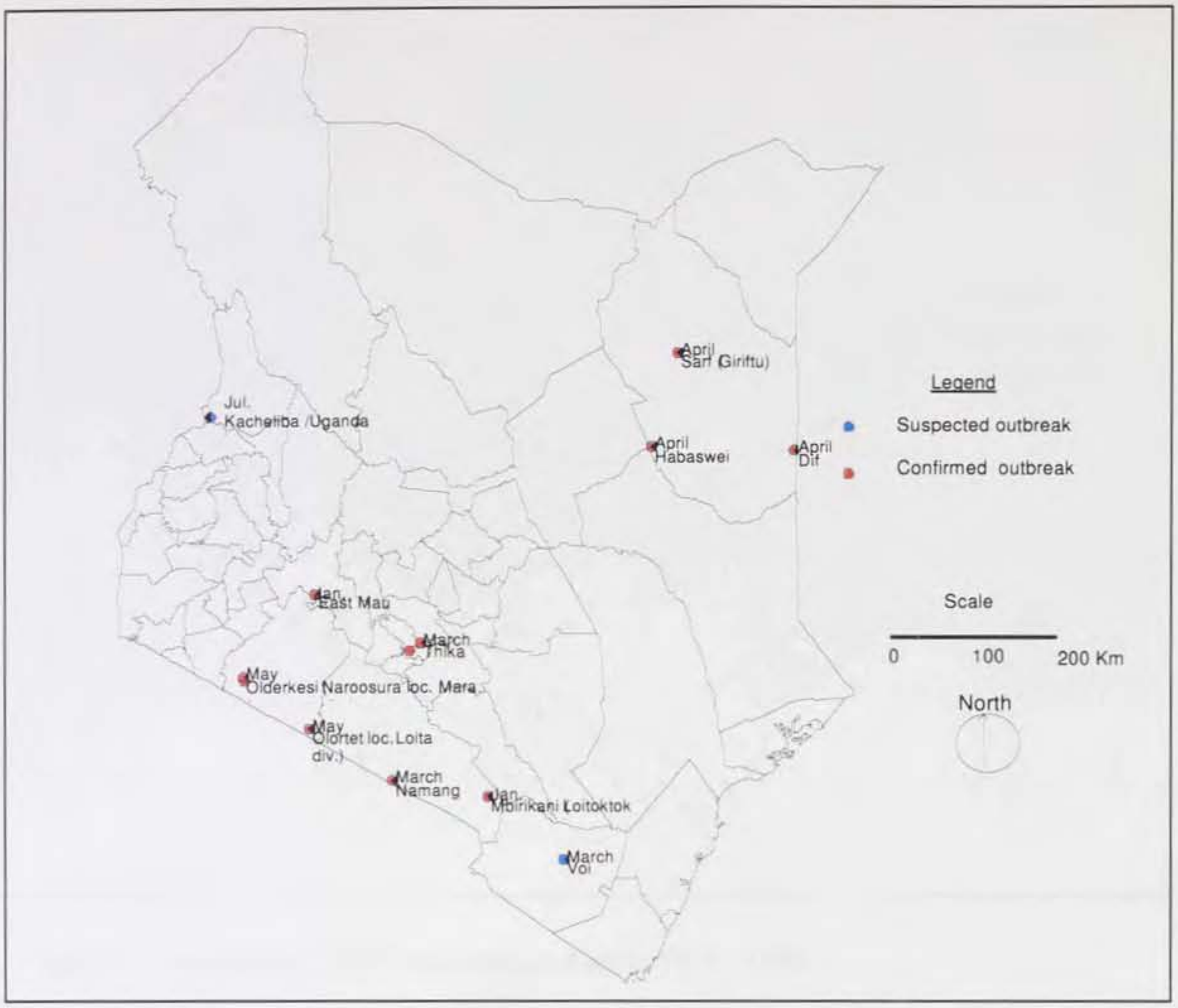


Figure 11: Map of CBPP outbreaks in Kenya in 1998

In 1998 new outbreaks were recorded in Wajir and Thika districts, in Narok and Kajiado districts close to the Tanzanian border. Suspected outbreaks were recorded in West pokot close to the Ugandan border and also in Taita Taveta district (Fig. 11).

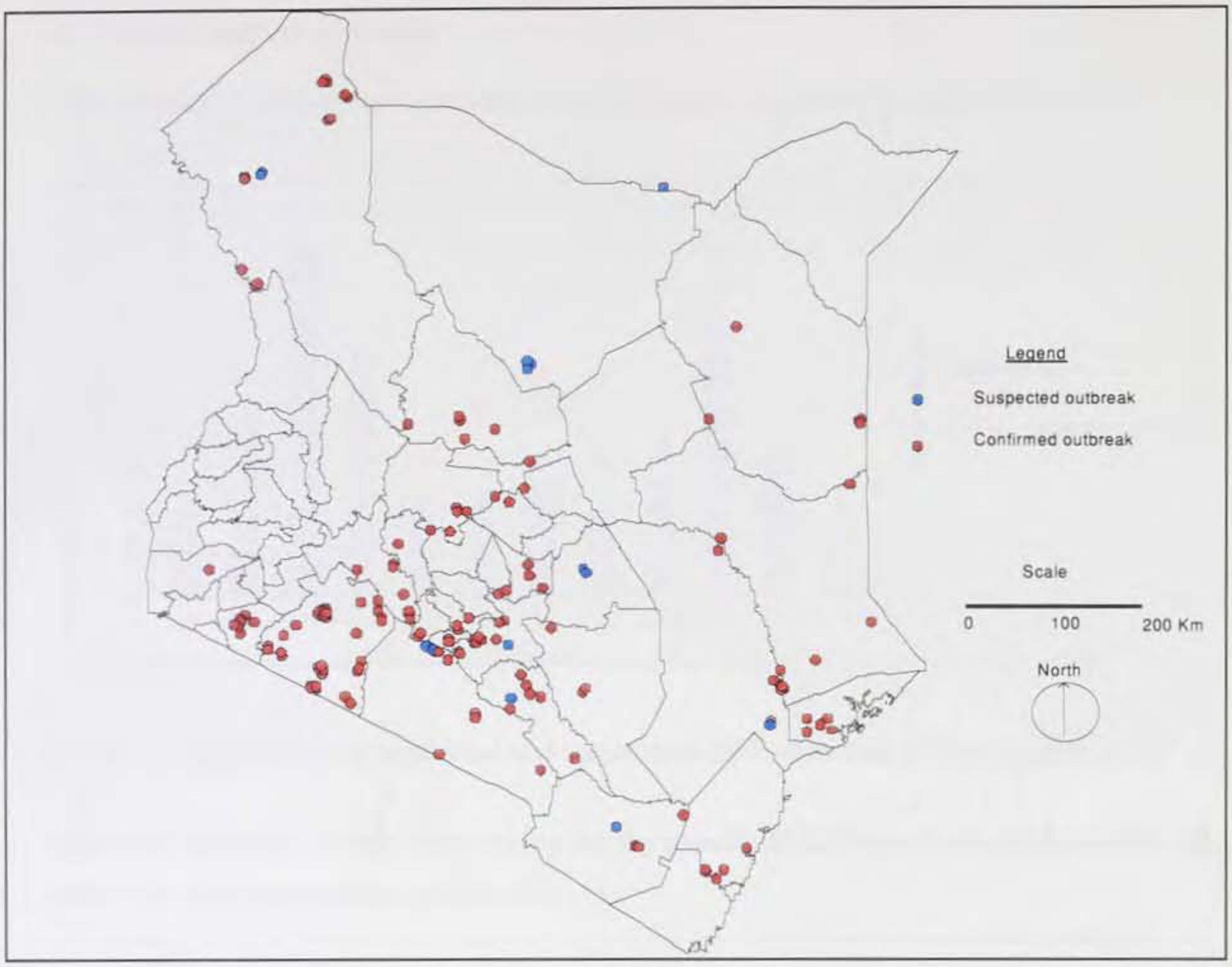


Figure 12: Summary of CBPP outbreaks in Kenya, 1989 - 1998.

When summarising the CBPP outbreak pattern for the last ten years the disease has spread into districts hypothetically known as clean districts of the Central province and to the Southern districts of Narok and Kajiado as well as to the Coast province (Fig. 12).

4.1.1 Seasonality of outbreaks

The seasonality of confirmed and suspected outbreaks is indicated in figures 13 and 14.

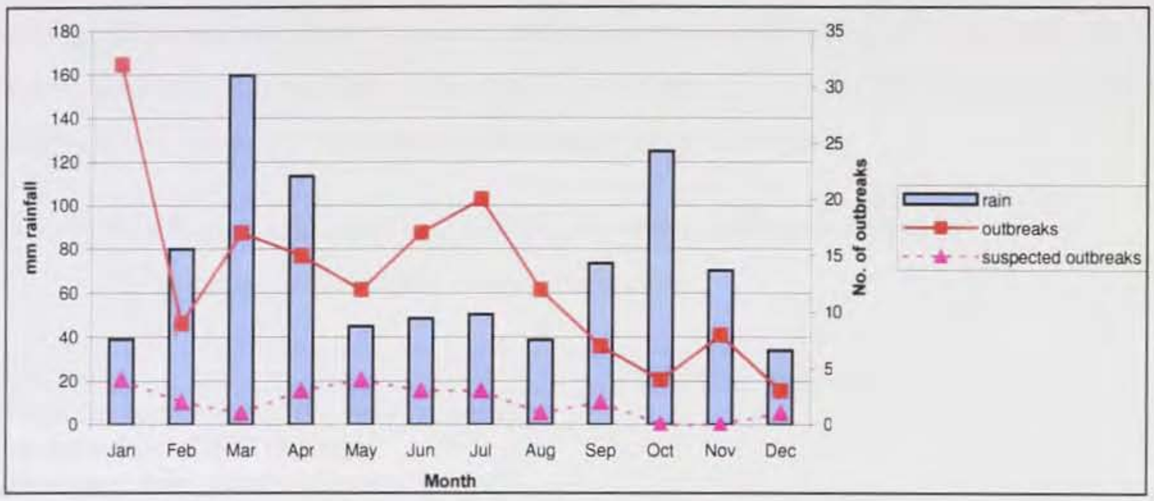


Figure 13 : Seasonality of confirmed and suspected CBPP outbreaks in Kenya, 1989-1998

Outbreaks appeared to occur more during the dry months declining at the beginning of the rains with slight increases during the rains (Fig. 13).

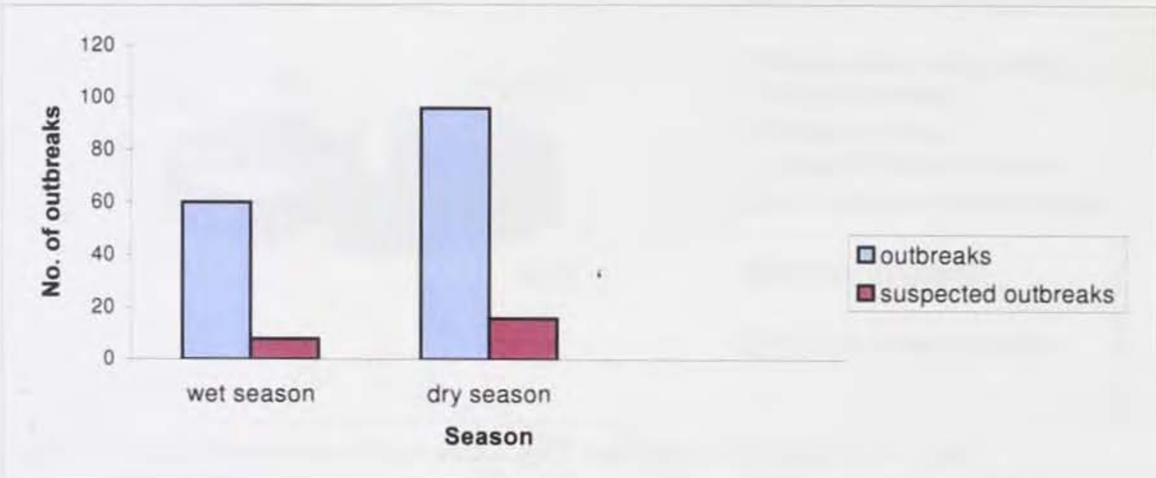


Figure 14: CBPP outbreaks during the wet and dry season in Kenya 1989-1998

About two thirds of the outbreaks were experienced during the dry months of January, May, June July, August and December while roughly one third of the outbreaks were experienced during the wet months of February, March, April, September, October and November (Fig. 14).

4.1.2 Traceback of outbreaks

Out of the 156 confirmed outbreaks, 53 (34%) were traced back by the Kenya Veterinary Department. A summary of trace back of outbreaks is listed under Annex 3. However, Table 4 and Fig. 15 summarise the risk factors identified and associated with CBPP outbreaks. The risk factors were related in one way or the other to movement. The action taken in terms of quarantine is indicated in Annex 11. Quarantine sometimes took up to 10 years.

Table 4: Risk factors associated with CBPP outbreaks according to reports by the Veterinary Department, Kenya, 1989-1998

Risk factor	Number of outbreaks
Illegal cattle movement for trade or grazing	19
Purchase from CBPP districts	11
Movement from slaughterhouses to farms	9
Infected neighbour	6
Purchase from other markets	4
Transboundary migration	4
Total	53

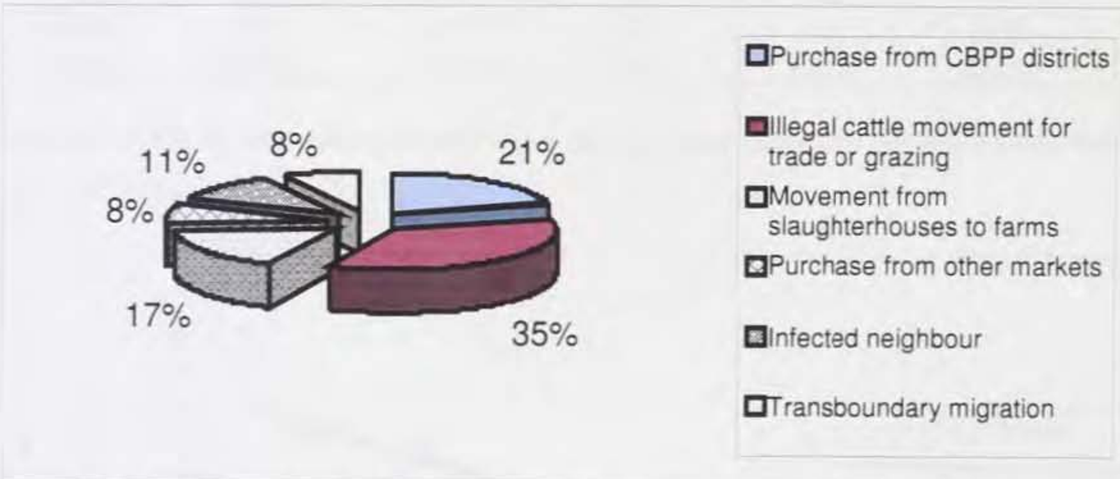


Figure 15: Risk factors associated with CBPP outbreaks in Kenya, 1989-1998

4.1.3 Confirmation of outbreaks

156 out of 191 outbreaks (82%) were confirmed by laboratory tests, 41 (33%) outbreaks were confirmed by laboratory CFT alone, 30 (24%) by both laboratory and field CFT, 28 (22%) by both laboratory and field CFT and by AGID, 13 (10%) by field laboratory test only, 12 (9%) by laboratory CFT and AGID, and 3 (2%) by field CFT and AGID.

Laboratory results

Laboratory complement fixation test results for serum samples and Agar Gel Immunodiffusion test for results for lung samples arriving at the CVL, Kabete, for the confirmation of a CBPP outbreak are given in Table 5 for serum samples and in Table 6 for lung samples. Laboratory results for serum samples per district are indicated in Annex 4a.

Table 5: CBPP Laboratory CFT results for serum samples by year, Kenya, 1989-1998.

Year	No. of serum samples submitted	No. positives	No.suspects	No. of total reactors	% positive (reactors and suspects)
1989	3538	137	64	201	5.7
1990	2162	57	56	113	5.2
1991	1204	239	80	319	26.5
1992	2045	147	140	287	14.0
1993	624	63	62	125	20.0
1994	454	22	18	40	8.8
1995	1369	29	17	46	3.4
1996	974	51	35	86	8.8
1997	796	90	62	152	19.1
1998	85	16	0	16	18.8
Total	13251	851	534	1385	10.5

In total 10.5% of serum samples arriving in the laboratory between 1989 and 1998 were positive for CBPP (Table 5).

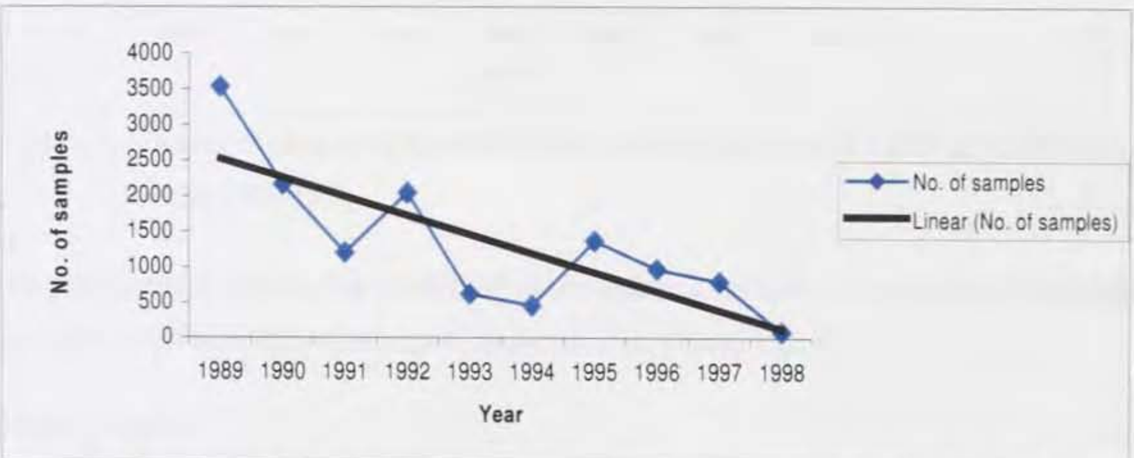


Figure 16: Number of serum samples submitted for the confirmation of CBPP at the CVL in Kenya, 1989-1998

Table 6: CBPP Agar Gel Immunodiffusion results for lung samples by year at the CVL, Kabete Kenya, 1989-1998.

Year	No. of lung samples submitted	No.positives	% positive
1989	19	16	84.2
1990	75	51	68.0
1991	131	59	45.0
1992	57	13	22.8
1993	26	19	73.1
1994	15	7	46.7
1995	9	3	33.3
TOTAL	332	168	50.6

Overall 50.6% of the lungs arriving at the laboratory were confirmed for CBPP (Table 6). The Agar Gel Immunodiffusion results for lung samples per district are listed in Annex 4b.

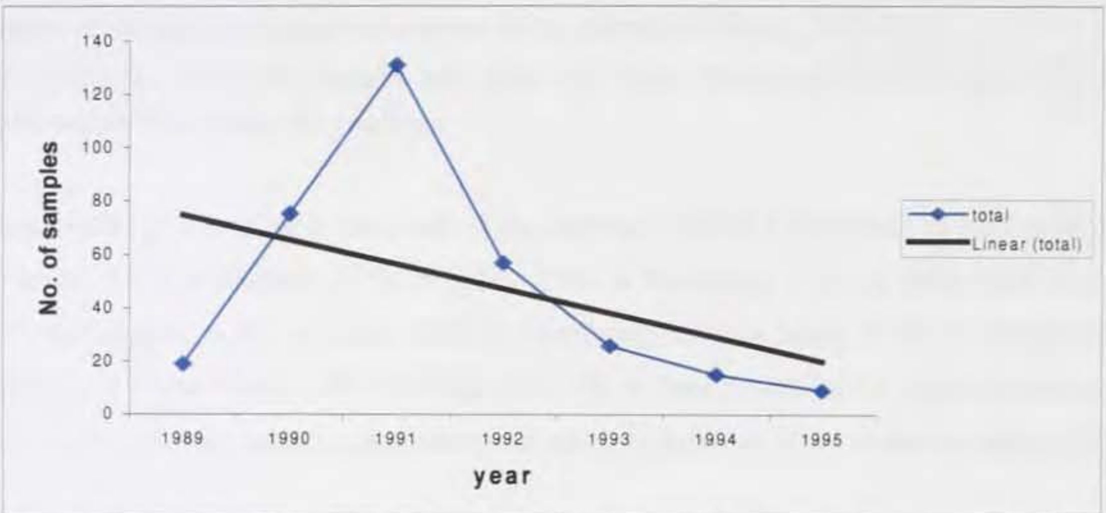


Figure 17: Number of lung samples submitted for the confirmation of CBPP at the CVL in Kenya, 1989-1998.

The general trend of declining number of serum and lung samples arriving at the laboratory for confirmation of over the years became apparent (Fig. 16 and Fig. 17).

Screening results

Cattle are screened for CBPP during CBPP outbreaks and upon movement from CBPP endemic districts. Screening is also done during the quarantine period in newly infected areas.

Figure 18 gives a summary of results of screening in the event of outbreaks per district using the field CFT.

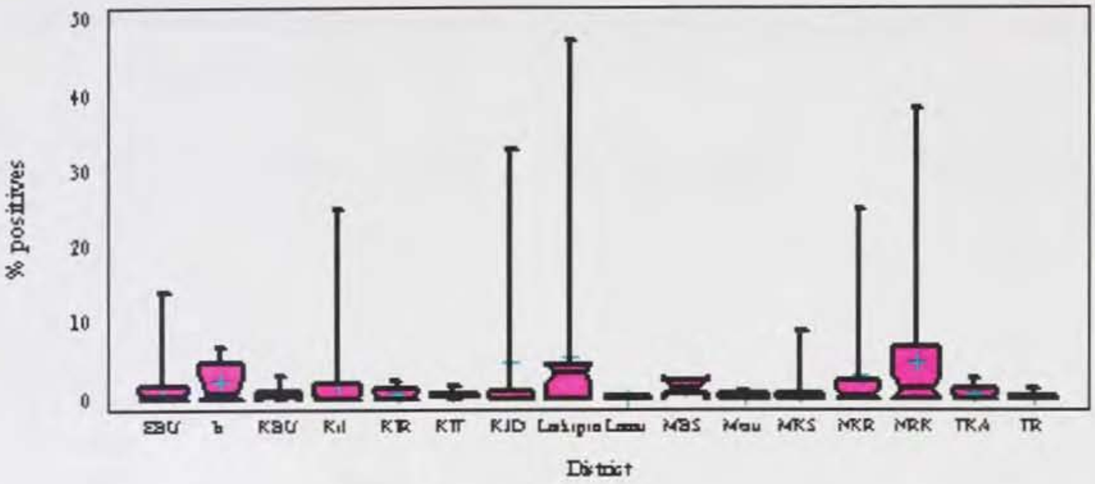


Figure 18: Screening results in the event of an outbreak in Kenya, 1989-1998

EBU=Embu Is= Isiolo KBU Kiambu Kil= Kilifi Kit= Kitui KJD=Kajiado MBS=Mombasa MKS=Machakos NKR=Nakuru TKA= Thika TR= Tana River

Thus results of screening in the event of an outbreak reached a maximum of 14% in Embu, 6.6% in Isiolo, 3.2% in Kiambu, 8.7% in Kilifi, 2.5% in Kirinyaga, 1.5% in Kitui, 32.9% in Kajiado, 47% in Laikipia, 0.5% in Lamu, 2.2% in Mombasa, 1.1% in Meru, 8.7% in Machakos, 25% in Nakuru, 38.1% in Narok, 2.6% in Thika and 1.4% in Tana River district. (Fig. 18). Thus, in newly infected districts the percentage positive was much higher than in the endemic districts (Fig 18).

Screening for movement

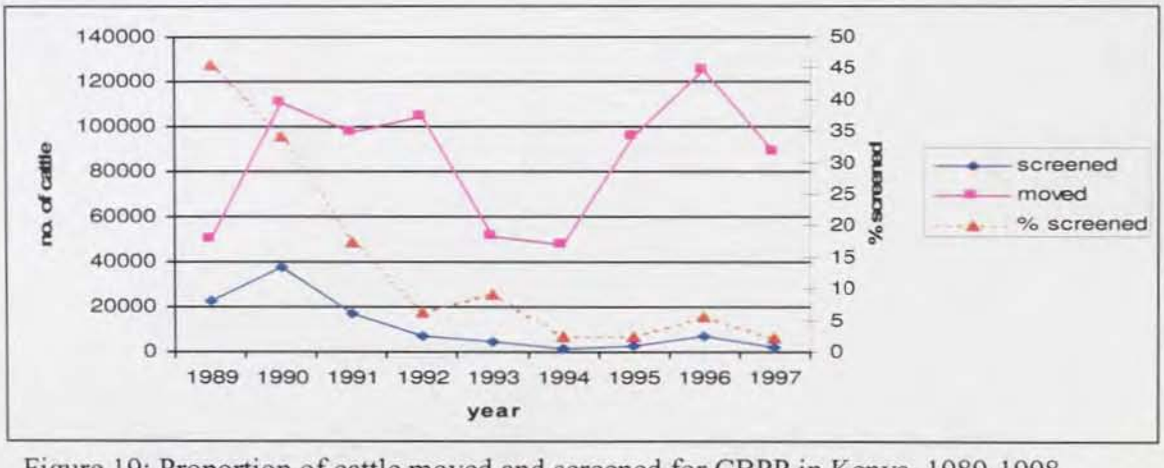


Figure 19: Proportion of cattle moved and screened for CBPP in Kenya, 1989-1998

The number of cattle screened for movement has declined tremendously over the years, from 45% in 1989 to 2% in 1997 (Fig.19).

Table 7: Proportion of cattle screened for movement that was positive in CBPP endemic districts, Kenya, 1989 to 1998

Year	Cattle screened	Number positive	% positive
1989	30856	6	0.02
1990	37976	20	0.05
1991	17099	11	0.06
1992	8737	15	0.17
1993	4951	49	0.02
1994	1308	1	0.08
1995	3683	0	0.00
1996	7655	1	0.01
1997	2012	0	0.00
1998	1938	0	0.00

The percentage positives in cattle screened for movement is very low reaching a maximum of only 0.17% in 1992 (Table 7).

4.2 Cattle movement patterns

CBPP has been described as a disease of moving cattle and movement in Kenya takes three forms i.e. movement for trade, transhumance in search of pastures and water, and theft or rustling. These movements and their relationship to outbreaks are illustrated in Fig. 20 and 21.

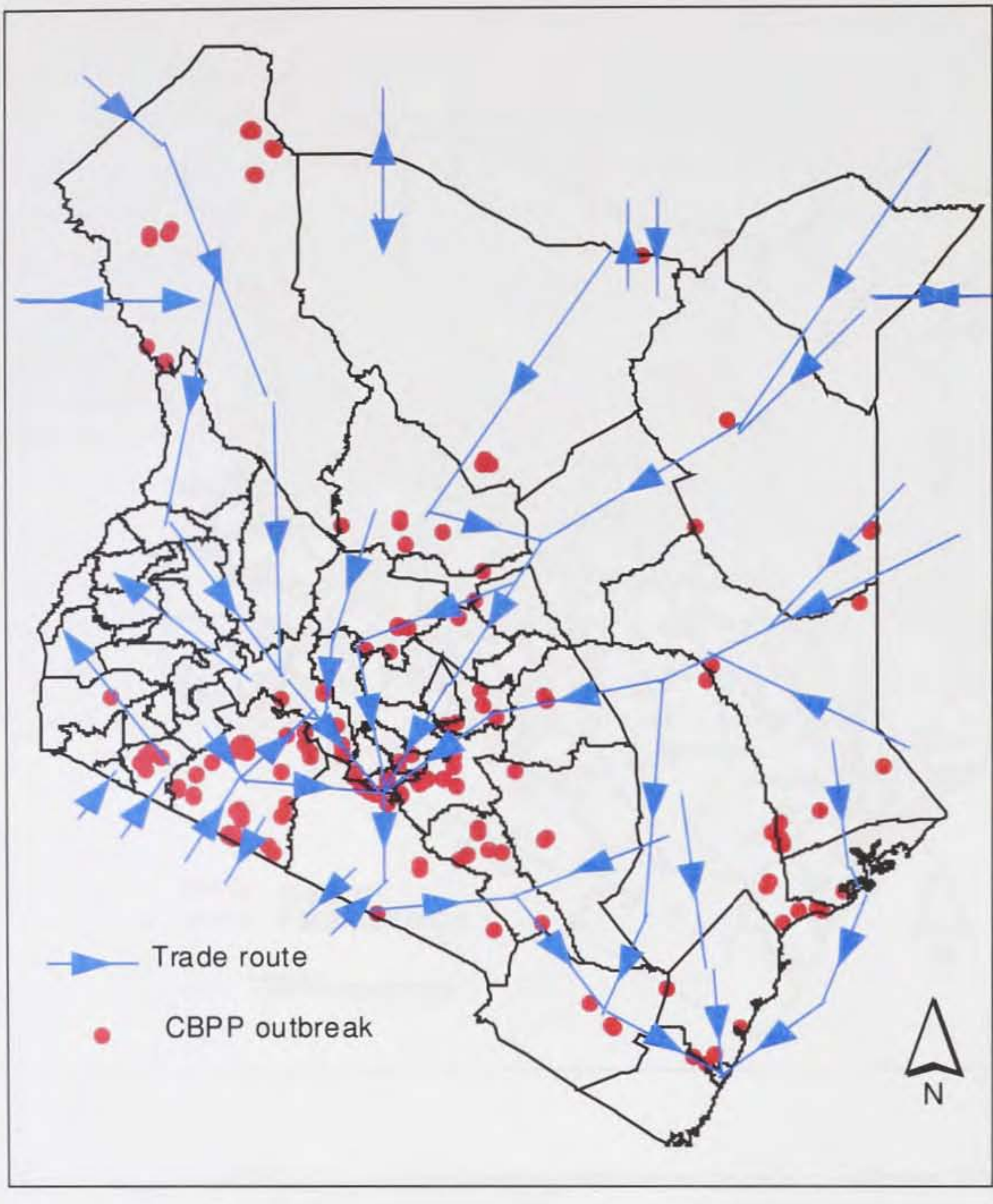


Figure 20: Map of cattle trade movement patterns and their relationship to outbreaks, Kenya.

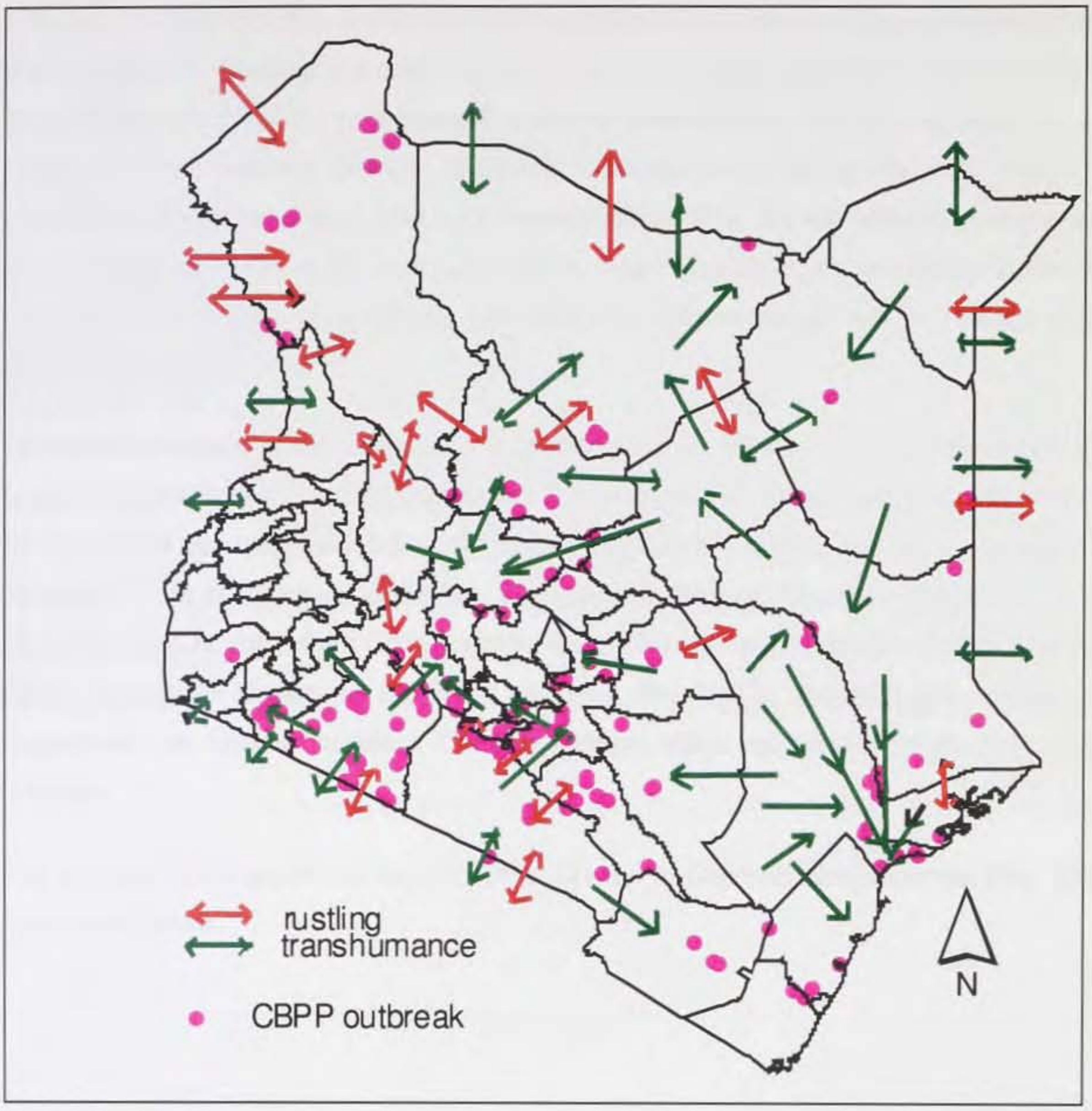


Figure 21: Map of cattle transhumance and rustling and their relationship to outbreaks, Kenya

Thus, movement for trade is mainly towards the densely populated districts of Nairobi and Kiambu, the Coast province districts of Kilifi and Mombasa and the lake region traversing clean districts Fig. 20). Rustling and transhumance are mainly among pastoralist communities in the endemic districts (Fig.21). Transnational boundary transhumance, rustling and trade are also evident in these endemic districts. Outbreaks occurred mainly along the trade routes and especially at the points of entry from neighbouring districts (Fig. 20) and where there is prevalent transhumance especially at the river Tana delta in Tana river district and in Laikipia district and where there is rampant cattle rustling particularly in Makueni district and in Turkana district neighbouring Uganda (Fig. 21).

Control of movement of cattle especially from endemic areas but also from non-infected districts is one of the methods of control. This implies that cattle moved for trade are only allowed to do so with a valid movement permit from the district of origin issued upon production of a valid "no objection" from the destination district. For instance, most of the cattle slaughtered at the Dagoretti complex arrive from CBPP endemic areas. This can be devised from Annex 13 and 14 where the top 10 districts in supply of cattle for slaughter at Dagoretti and countrywide, respectively, are districts in which CBPP is resident either endemically or due to a recent infection.

The origin of cattle moved countrywide (Fig. 22) and to Dagoretti slaughterhouse (Fig. 23) is summarised below.

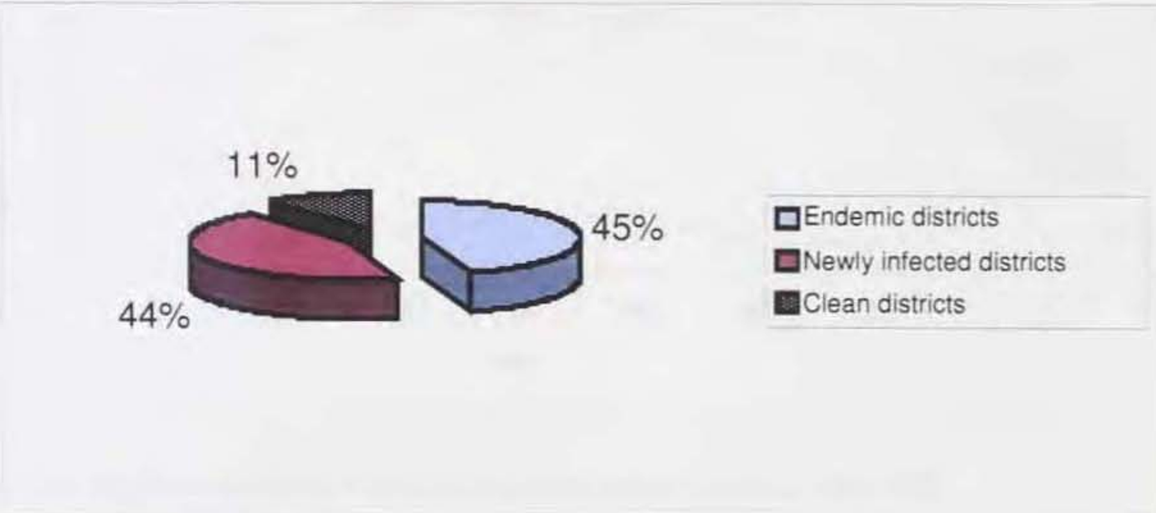


Figure 22: Origin of cattle moved countrywide, Kenya, 1989-1997

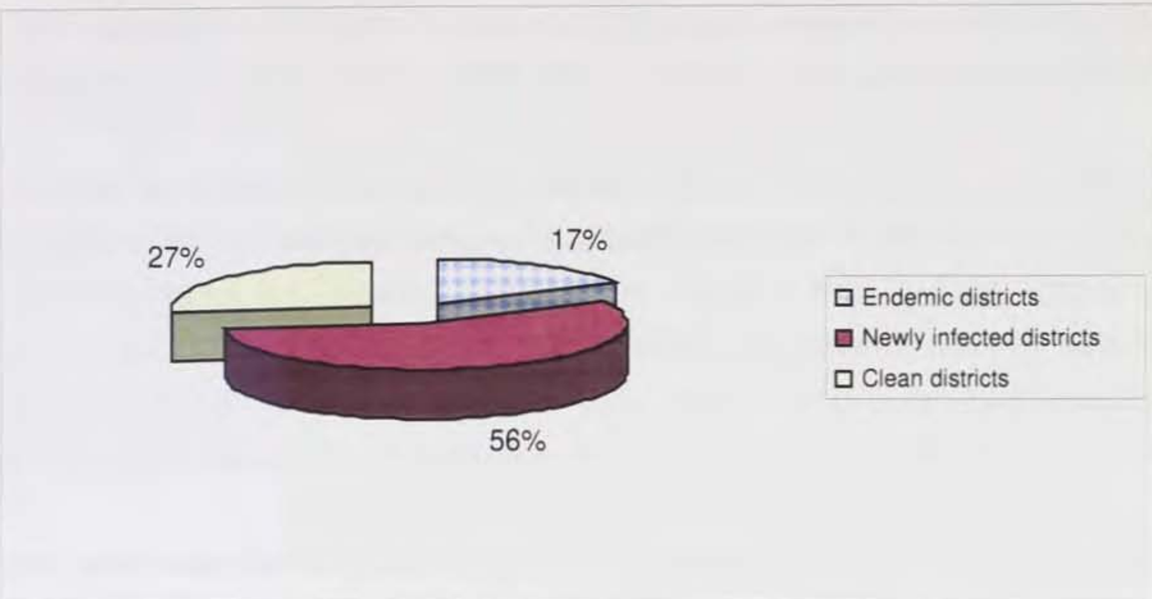


Figure 23: Origin of cattle moved to Dagoretti slaughter complex,Kenya, 1991-1998

The mode of movement of cattle into the Dagoretti complex has changed over the years. In the last five years over 80% of cattle were moved by vehicle compared to 60% in 1991 (Fig. 24). It is also worth noting that almost all the remaining cattle (less than 20%) moved on hoof stemmed from the neighbouring Kajiado district which is a CBPP newly infected district.

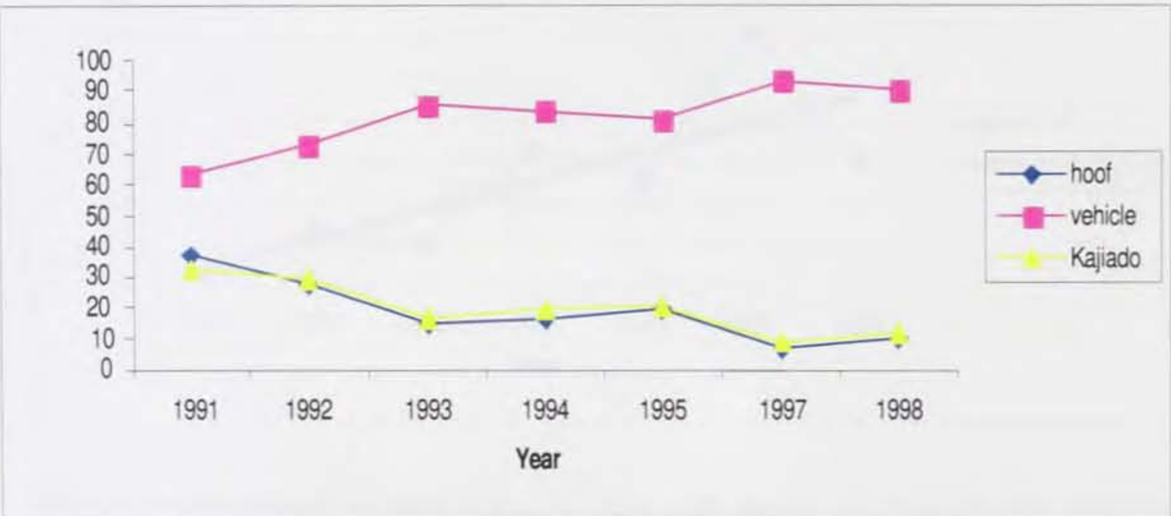


Figure 24: Mode of transport of cattle to Dagoretti complex, Kenya, 1991-1998

The correlation between the number of cattle indicated in the permits and those that eventually arrived at the slaughterhouse (Annex 5) was found to be relatively strong and statistically significant in 1991 ($r = 0.984$, $p<0.01$), 1992 ($r = 0.927$, $p<0.01$) and 1993 ($r = 0.946$, $p<0.01$). The relationship was found to be moderately strong and statistically significant in 1994 ($r = 0.820$, $p< 0.01$), 1995 ($r = 0.863$, $p<0.01$), 1997 ($r = 0.623$, $p<0.01$) and 1998 ($r =0.835$, $p<0.01$).

However, the scenario changed when all animals with and without permits were considered. The relationship was still relatively strong and statistically significant in 1991 ($r = 0.976$, $p<0.01$) and moderately strong and statistically significant in 1992 ($r = 0.884$, $p<0.01$), 1993 ($r =0.646$, $p<0.01$) and 1997 ($r = 0.620$, $p<0.01$). The relationship was, however, relatively weak but still statistically significant in 1994 ($r = 0.392$, $p<0.01$), 1995 ($r = 0.415$, $p<0.01$) but extremely weak (even negative) and statistically insignificant in 1998 ($r = -0.008$, $p>0.10$).

It is worth noting that while cattle moved in consignments of 20 (districts over 300 km from the slaughterhouse) to 30 (districts less than 300 km from the slaughterhouse), cattle from Kajiado moved in consignments of up to 200 on hoof! (Annex 5). The cattle moved without permits reached 13% and 90% of these were from Kajiado district (Annex 19).

However, the unexplained variation ($1-r^2$) in cattle with permit and cattle delivered had been increasing constantly over the years as demonstrated in Fig. 25.

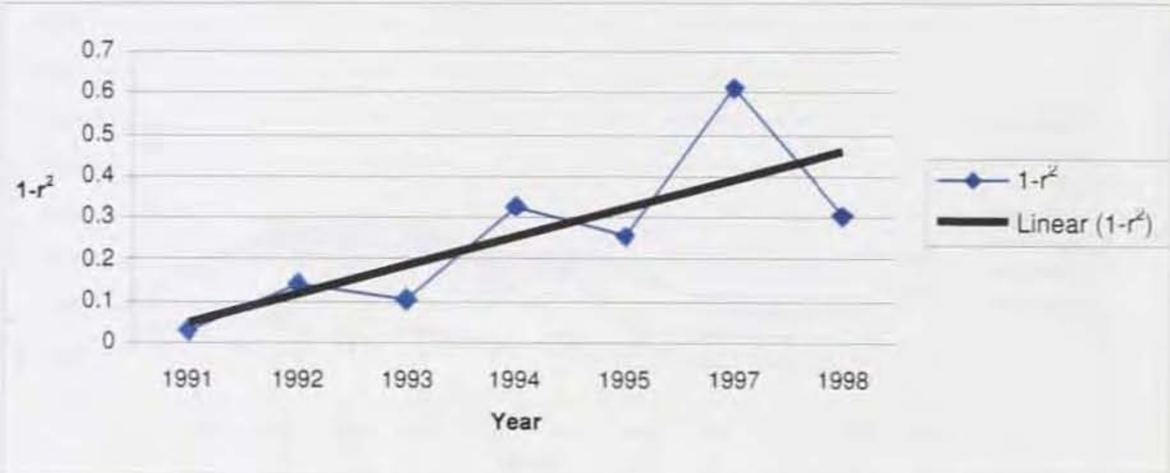


Figure 25: Unexplained variation of head of cattle with permits and head of cattle delivered to Dagoretti complex, Kenya, 1991-1998

Rarely cattle arrived at the Dagoretti complex with unknown origin (up to 2.14%); cattle arrived mainly by vehicle and half the time with permits (Fig. 26).

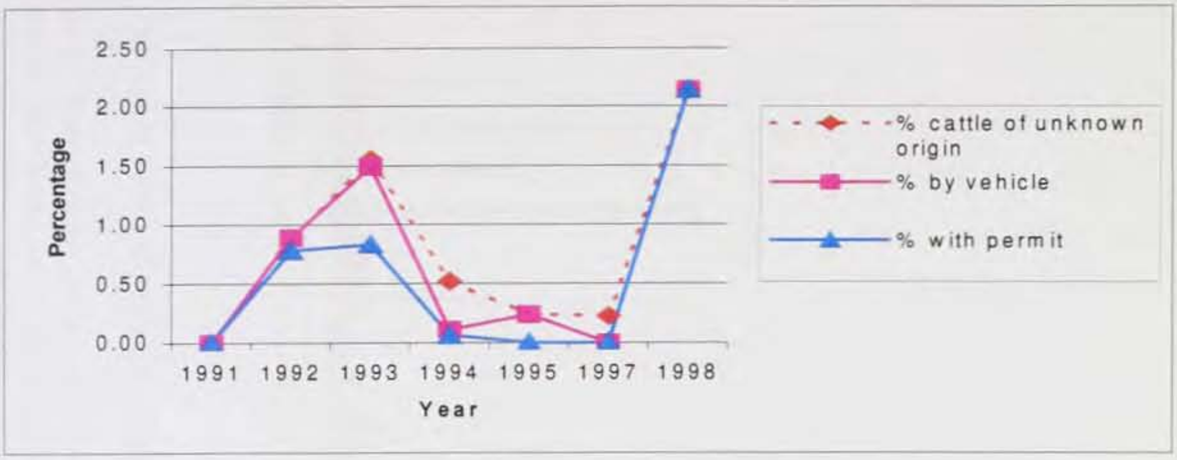


Figure 26: Cattle of unknown origin moved to Dagoretti complex, Kenya, 1989-1998

The movement of cattle per month for 1991 to 1998 excluding 1996 is presented in Fig. 27

The difference between the months was found to be not statistically significant ($p \geq 0.05$) at the 95% confidence level but the difference between the years was found to be statistically significant ($p < 0.05$) using the Kruskal Wallis test.

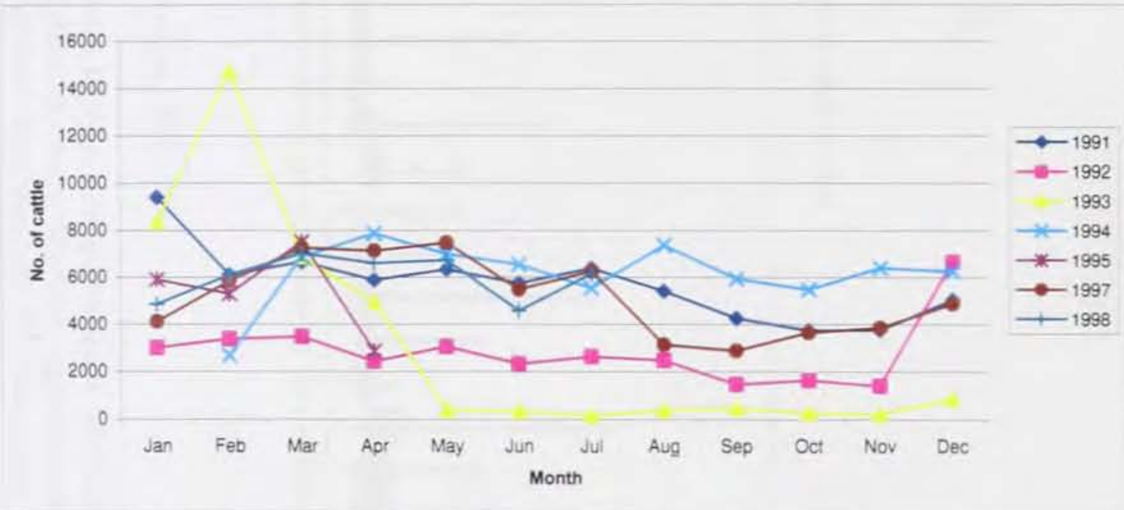


Figure 27: Monthly movement of cattle to Dagoretti complex of Kenya 1991-1998

A worrying phenomenon is the tendency for cattle to take too long to arrive at the slaughterhouse. While cattle should normally take up to 10 days (farthest districts) and an average of 3-4 days(medium distance districts) and 1-2 days from near districts, it is common to observe animals taking up to 30-40 days to arrive (Fig. 28)

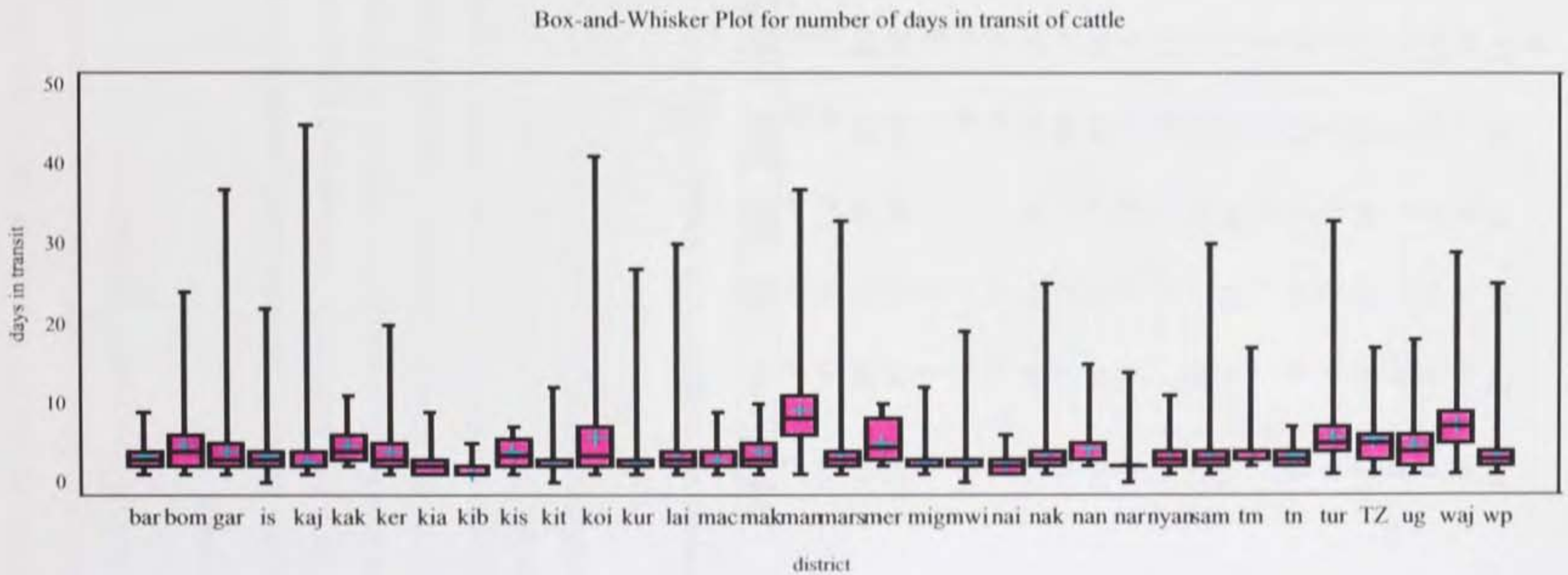


Figure 28: Days in transit of cattle moving to Dagoretti slaughter complex, Kenya, 1989-1998

bar=Baringo bom=Bomet gar=Garissa is=Isiolo kaj=Kajiado kak=Kakamega ker=Kericho kia=Kiambu kib=Kibiko kis=Kisumu kit=Kit
koi=Koibatek kur=Kuria lai=Laikipia mac=Machakos mak=Makueni man=Mandera mars=Marsabit mer=Meru mig=Migori mwi=Mwingi
nai=Nairobi Nak=nakuru nan=Nandi nar=Narok nyan=Nyandarua sam=Samburu tm=Transmara tn=Trans nzoia tur=Turkana TZ=Tanzan
ug=Uasin Gishu waj=Wajir wp=West Pokot

In the far and endemic districts of Garissa, Mandera, Marsabit, Turkana and Wajir, greater variations were seen in the days in transit. Inspite of being near districts, in Kajiado, Koibatek and Laikipia up to 30-40 days in transit were observed.

4.3 Vaccination coverage

Because of socio-cultural and economic factors, vaccination is the method of choice to reduce the incidence of CBPP in a first step before strict sanitary measures towards eradication can be applied. As vaccination in Kenya is biannual, a coverage of 200% is expected. Evaluation of the vaccination coverage in the districts vaccinating indicated desirable 200% are almost never achieved (Table 8). Cattle population estimates and CBPP vaccination figures used to calculate vaccination coverage are found in Annex 16 and Annex 17, respectively. The georeferenced mapping of vaccination coverage is illustrated in Figures 29 to 38.

Table 8: CBPP vaccination coverage (in %) in Kenya, 1989-1998

District	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Bungoma	0	2	0	0	0	0	0	0	0	
Busia	17	9	0	0	0	0	0	0	0	
Garissa	47	41	26	103	37	15	89	23	14	41
Isiolo	0	24	37	4	46	144	72	31	43	
Kajiado	0	0	3	0	5	5	6	3	25	3
Kiambu	0	0	0	1	1	0	0	1	3	
Kilifi	3	0	0	0	0	0	0	0	0	
Kitui	25	13	24	13	60	13	24	15		
Laikipia	0	0	0	2	0	10	2	0	4	0
Lamu	41	86	81	70	0	30	56	51	0	71
Machakos	0	0	0	9	0	0	4	0		
Makueni				0	0	9	11	3		
Mandera	0	18	30	5	16	104	20	0	0	0
Marsabit	17	23	10	52	65	83	115	43		
Mwingi					10	21	8	7		
Nairobi	0	0	0	0	6	35	0			
Nakuru	0	0	0	3	1	3	1	3	1	0
Narok	0	11	30	46	36	39	64	18	5	
Nyandarua	0	0	0	0	3	0	0	0	0	0
Samburu	0	0	0	0	0	10	25	78	0	0
Taita taveta	6	0	0	0	0	0	0	0	0	0
Tana river	39	30	34	29	43	36	35			17
Thika							0	4		3
Trans mara										
Turkana	13	23	0	16	9	17	21	33	0	25
Wajir	11	10	15	30	44	37	25	0	11	85
West pokot	42	25	38	27	13	49	65	40	35	

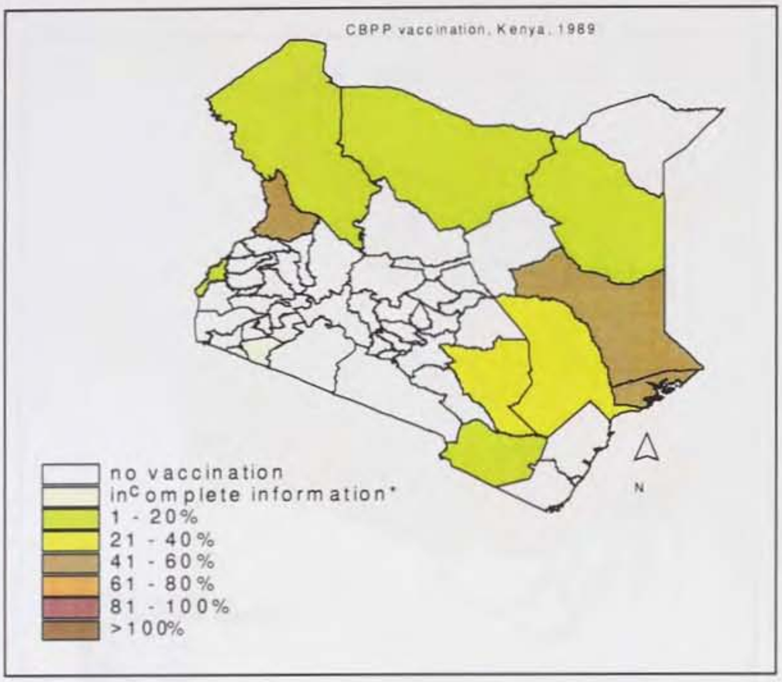


Figure 29: Map of CBPP vaccination coverage, Kenya, 1989

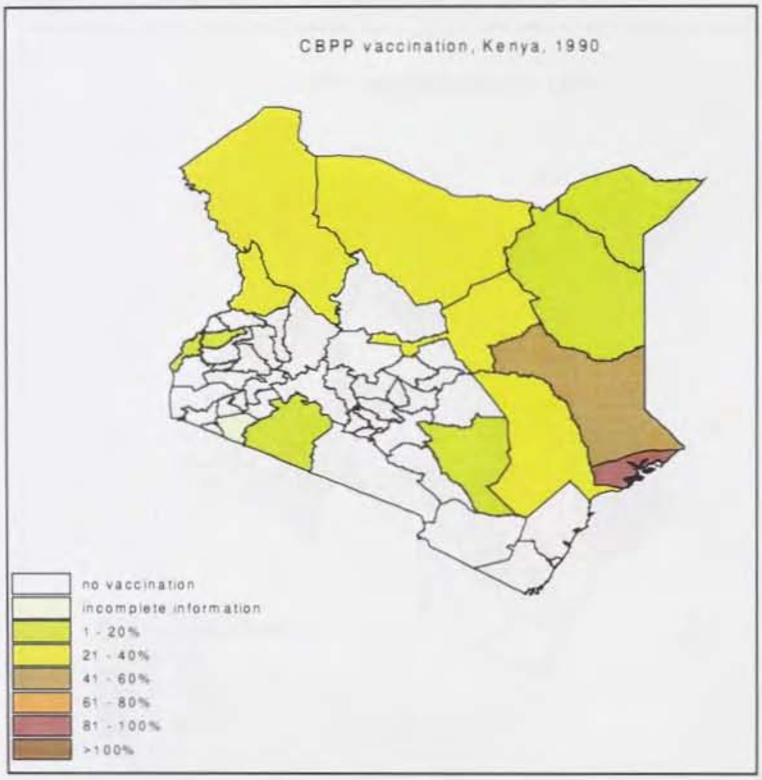


Figure 30: Map of CBPP vaccination, Kenya, 1990

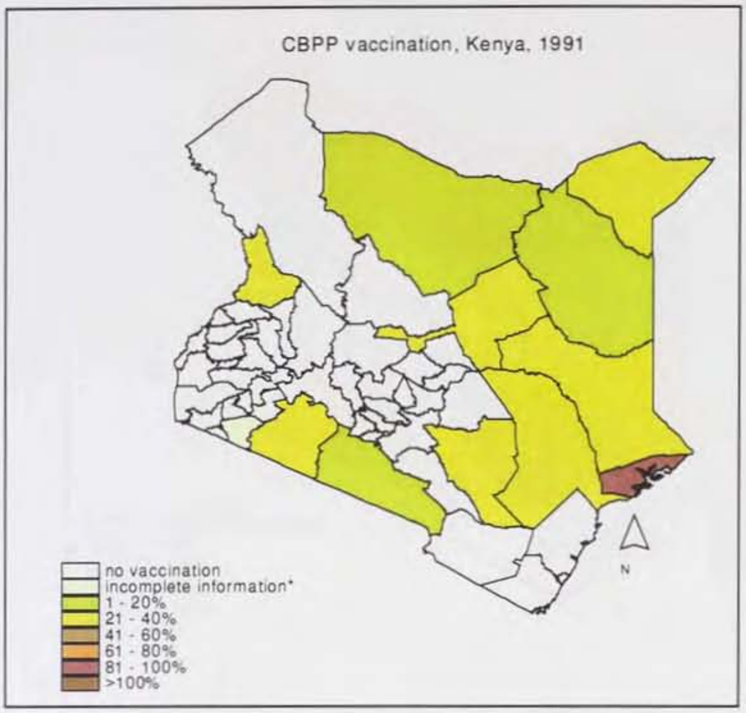


Figure 31: Map of CBPP vaccination, Kenya, 1991

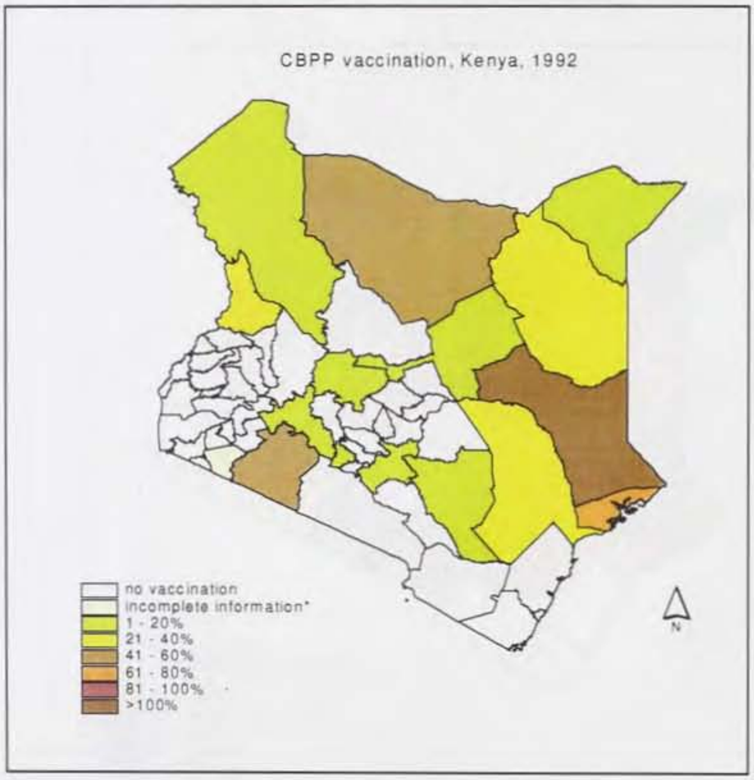


Figure 32: Map of CBPP vaccination, Kenya, 1992

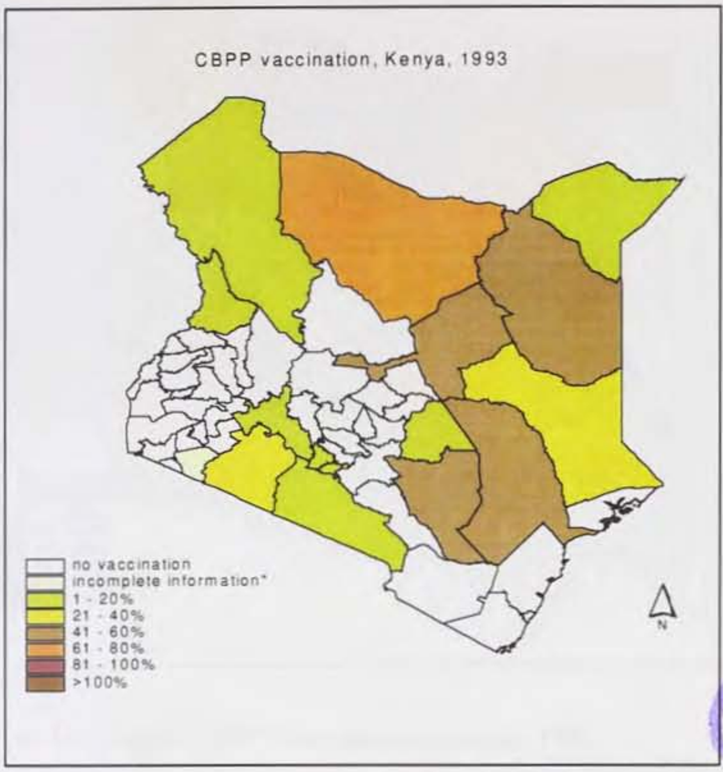


Figure 33: Map of CBPP vaccination, Kenya, 1993

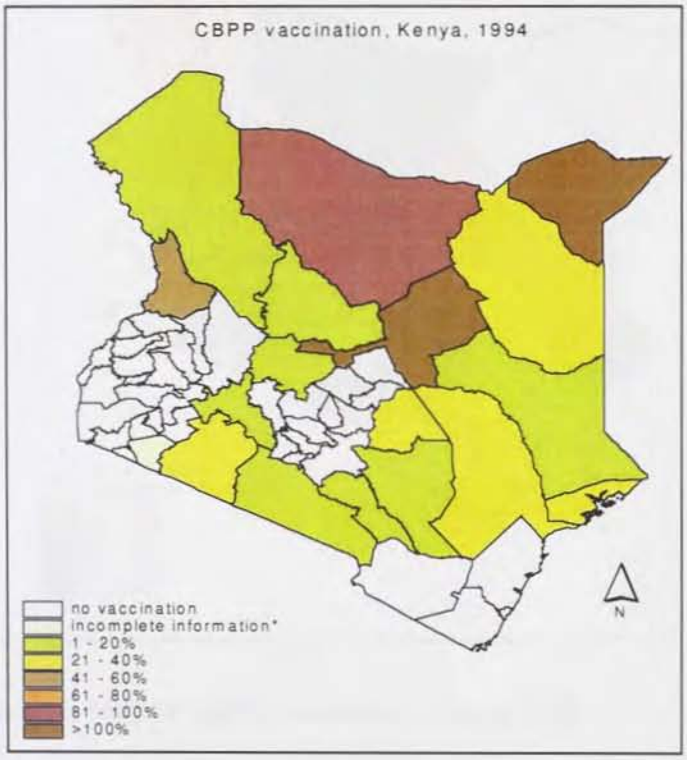


Figure 34: Map of CBPP vaccination, Kenya, 1994

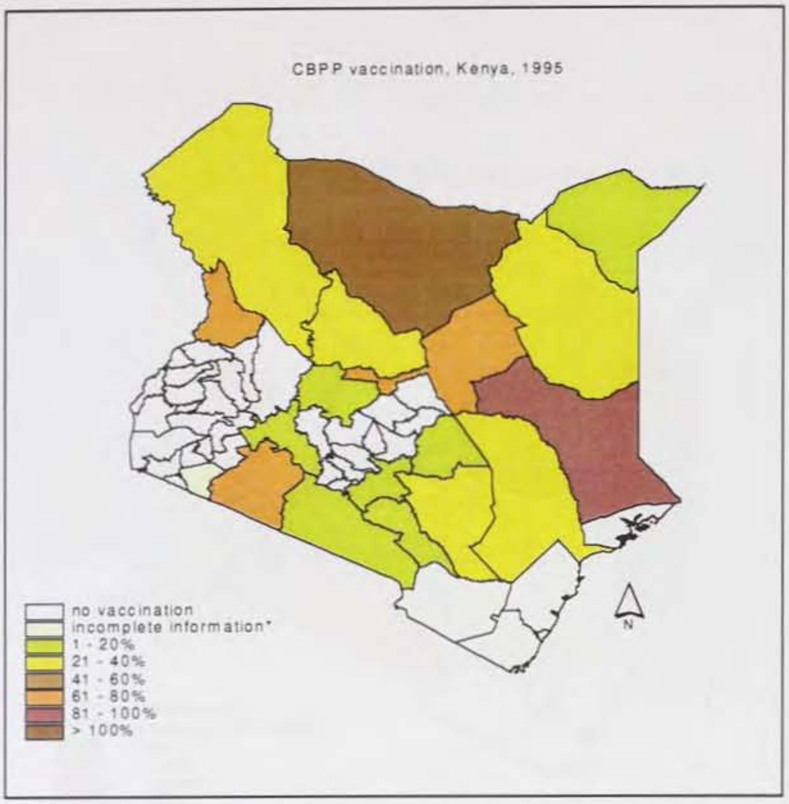


Figure 35: Map of CBPP vaccination, Kenya, 1995

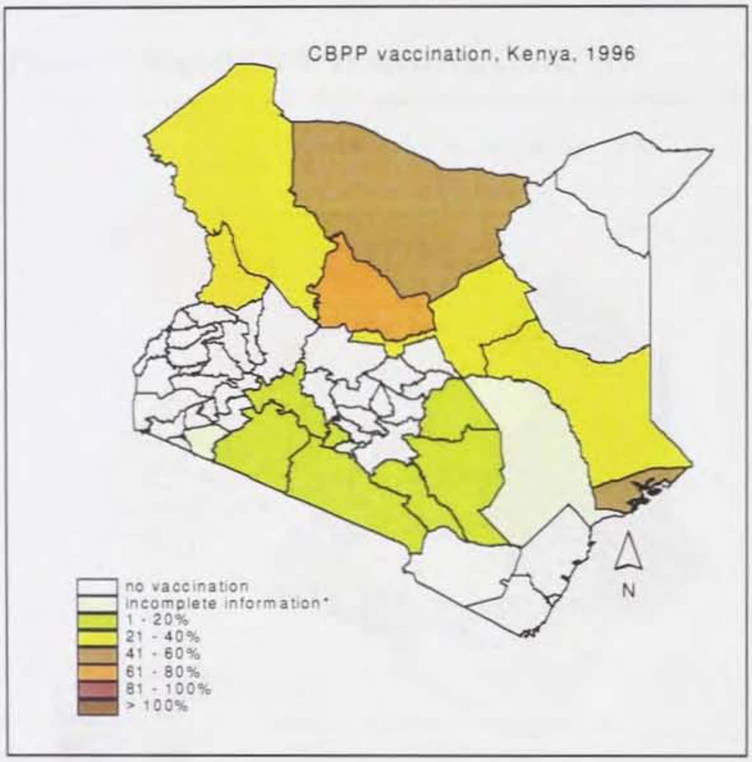


Figure 36: Map of CBPP vaccination, Kenya,1996

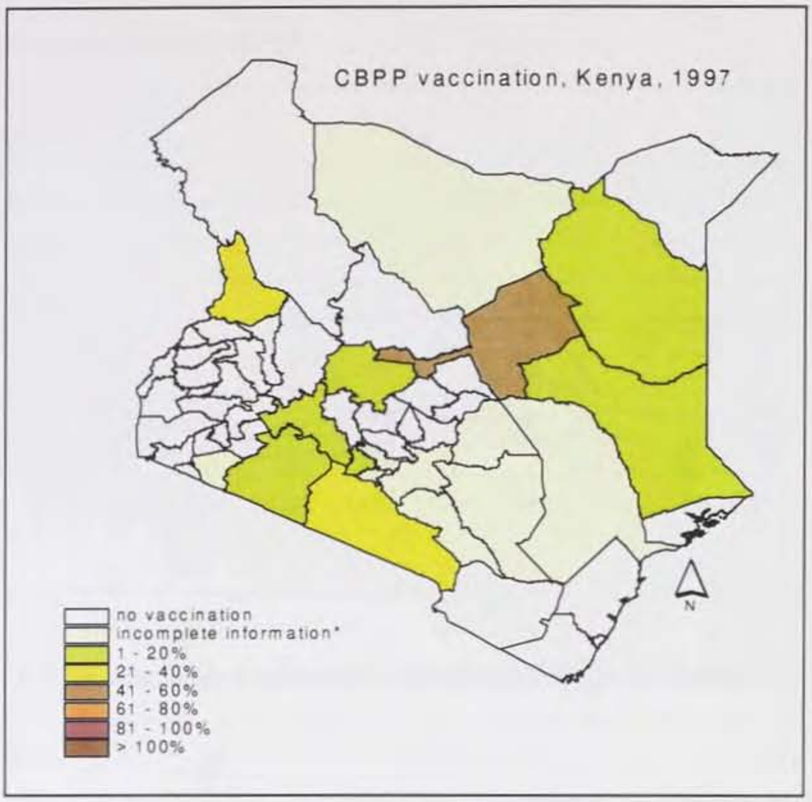


Figure 37: Map of CBPP vaccination, Kenya, 1997

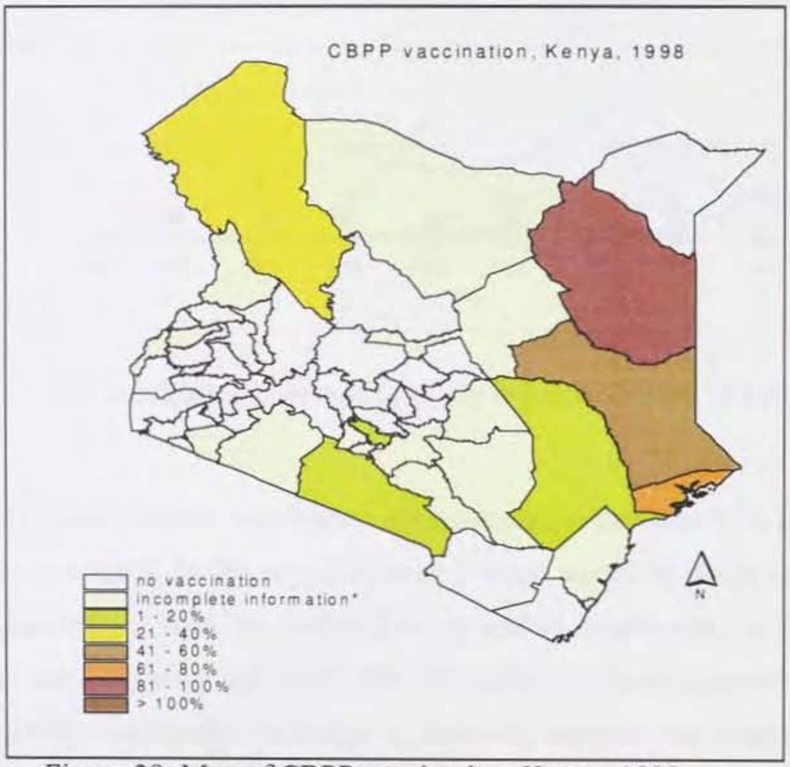


Figure 38: Map of CBPP vaccination, Kenya, 1998

* = lack of information on cattle population estimates

The secular trend of vaccination coverage is demonstrated in Fig. 39 for endemic districts and Fig. 40 for newly infected districts.

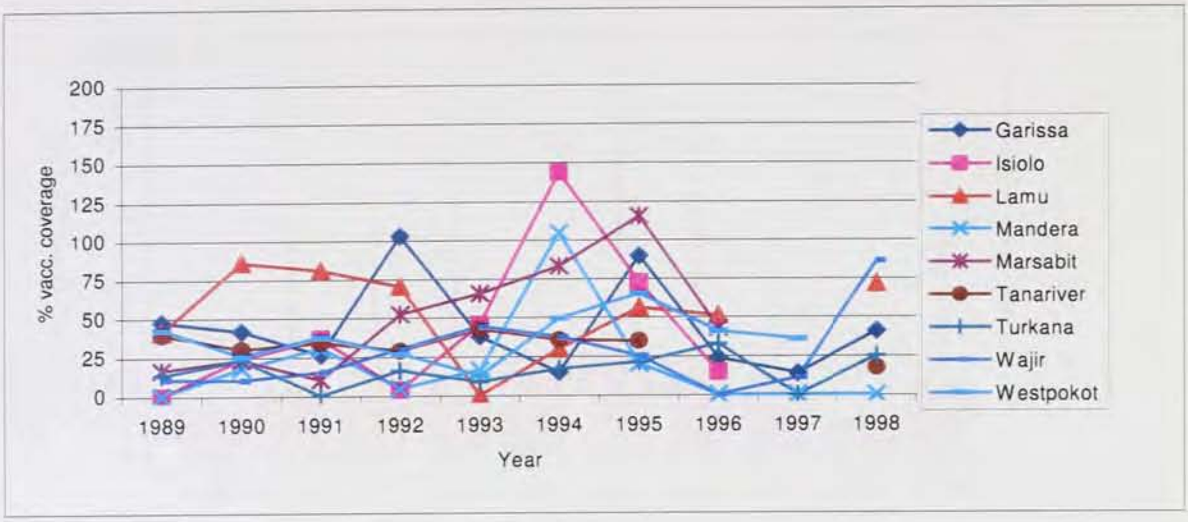


Figure 39: CBPP vaccination coverage in endemic districts of Kenya, 1989-1998

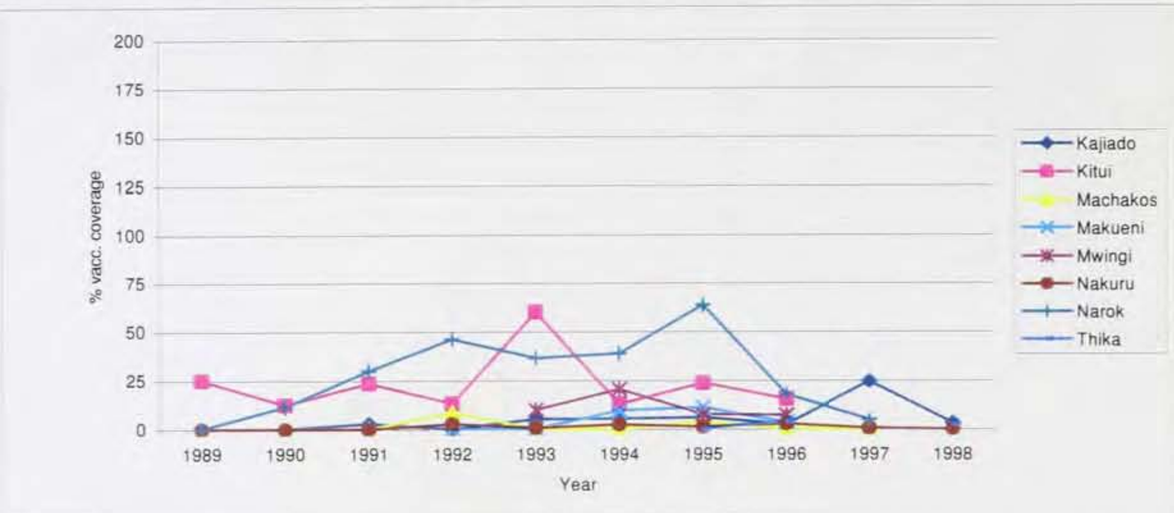


Figure 40: CBPP vaccination coverage in newly infected districts of Kenya, 1989-1998

In CBPP endemic districts vaccination coverage ranges between 25% and 75% but occasionally reaches beyond 100%. In the newly infected districts except in Narok and Kitui districts it rarely goes beyond 25%. It is in the border districts and its neighbours, i.e. Marsabit, Garissa, Wajir, Samburu, Lamu, Mandera and Isiolo that vaccination coverage occassionally reaches above 75% (Figures 29-38). Vaccination coverage is, however, irregular and sometimes missed out in some endemic districts as well as Tana River which consistently vaccinated had been on the decline. Using Kruskal Wallis test, vaccination between the years was found to be not significantly different (p>0.05) but significantly different (p>0.05) between the newly infected districts and the endemic districts with the exception of Narok (Figs 41 and 42).

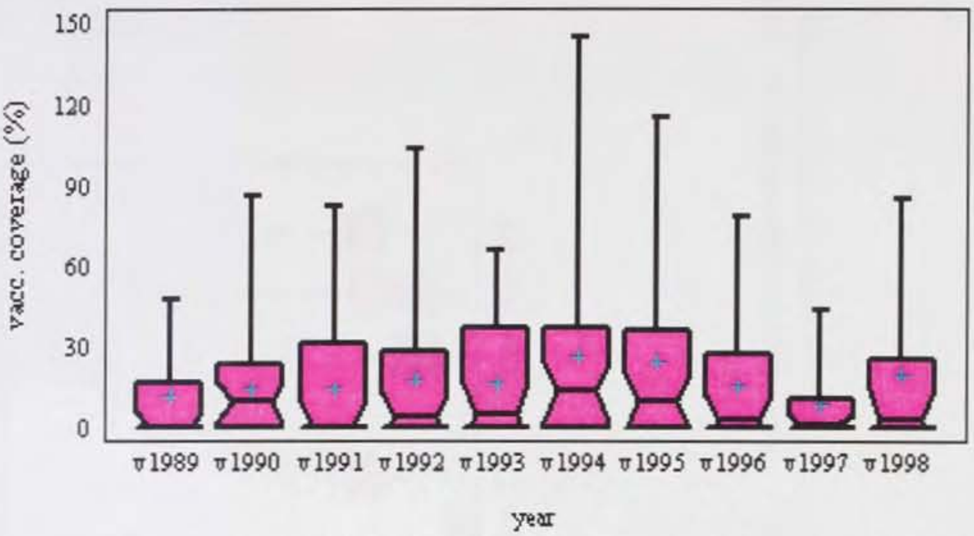


Figure 41: Box and Whisker plot of annual vaccination coverage in Kenya, 1989-998

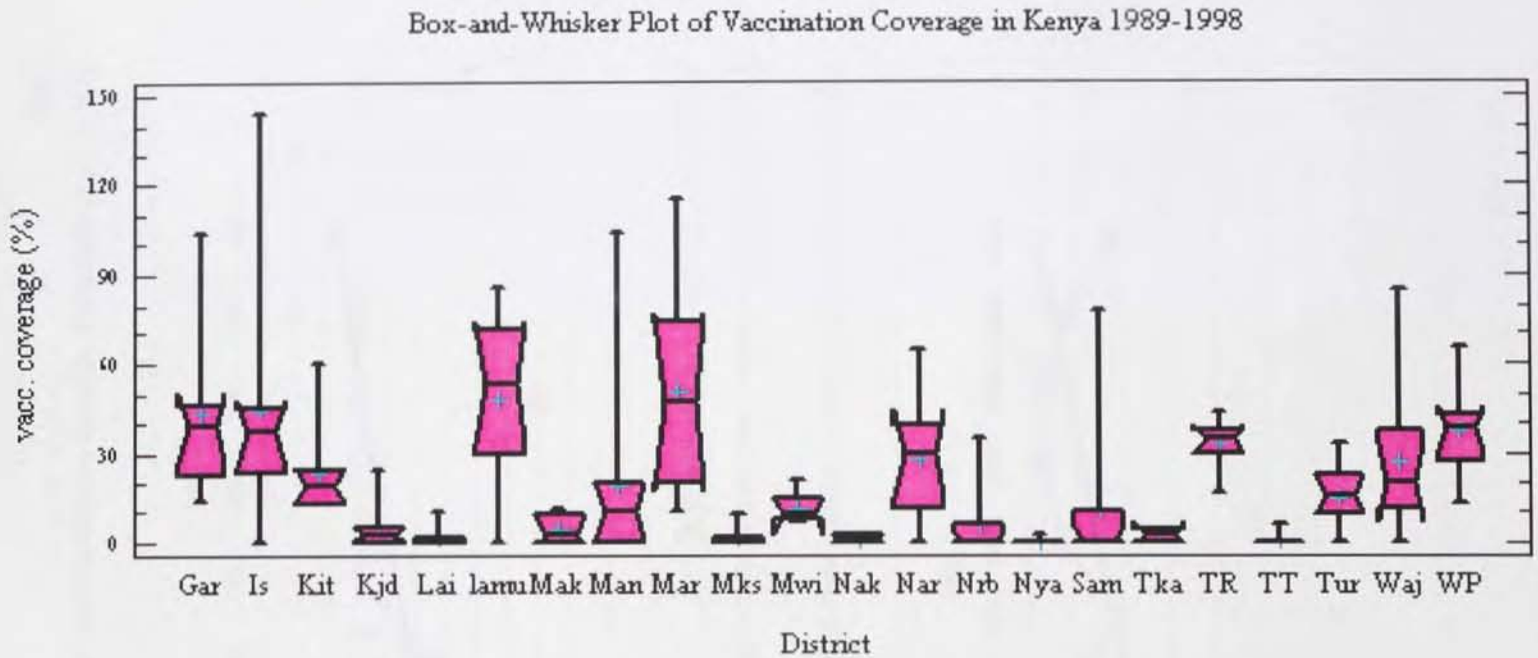


Figure 42: CBPP vaccination coverage by district in Kenya, 1989-1998

Gar=Garissa Is=Isiolo Kjd=Kajiado Lai=Laikipia Mak=Makueni Man=Mandera Mar=Marsabit Mks=Machakos Mwi=Mwingi Nak=Nakuru Nar=Narok Nrb=Nairobi Nya=Nyandarua Sam=Samburu Tka=Thika TR=Tana river Tur=Turkana Waj=Wajir WP=West Pokot

When correlating the figures for vaccine distributed and vaccine actually used the relationship was relatively strong and statistically significant in 1990 ($r = 0.92$, $p<0.01$), 1991 ($r = 0.96$, $p<0.01$), 1992 ($r =0.97$, $p<0.01$), 1993 ($r = 0.93$, $p<0.01$) and 1995 ($r =0.91$, $p<0.01$); however, it was moderately strong but statistically significant in 1989 ($r = 0.80$, $p<0.01$), 1994 ($r=0.79$, $p< 0.01$), 1996 ($r=0.77$, $p<0.01$) and 1997 ($r=0.70$, $p<0.01$). Only in 1998 the relationship was relatively weak and statistically insignificant ($r=0.17$, $p\geq0.10$). However, the general trend was an increase in unexplained variation between vaccine distributed and actually used (Fig. 43).

Vaccination distribution and use figures are to be found in Annex 18.

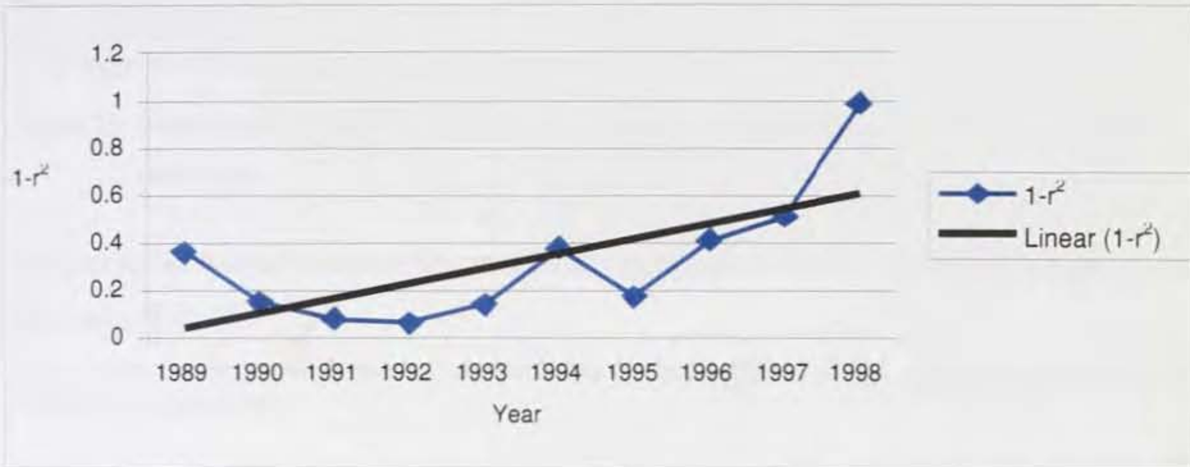


Figure 43: Unexplained variation between vaccine distributed and actually used in Kenya, 1989-1998.

The relationship between vaccination and outbreaks is indicated in Figure 44 (for endemic regions) and Figure 45 (for Narok district).

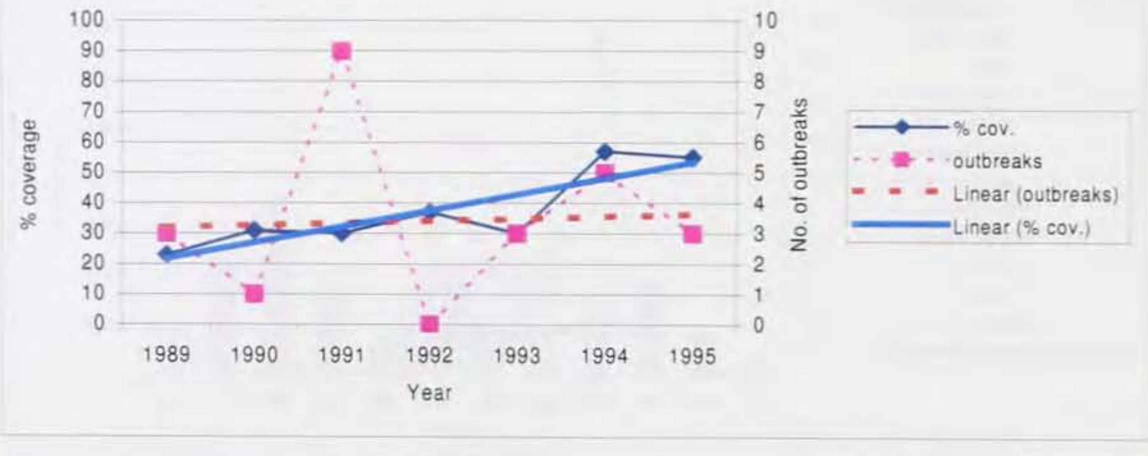


Figure 44: Relationship between vaccination and outbreaks in CBPP endemic districts, Kenya, 1989-1995

With an average vaccination coverage of 20-60% in endemic districts in the last ten years outbreaks stabilised at between 3 and 4 per year.

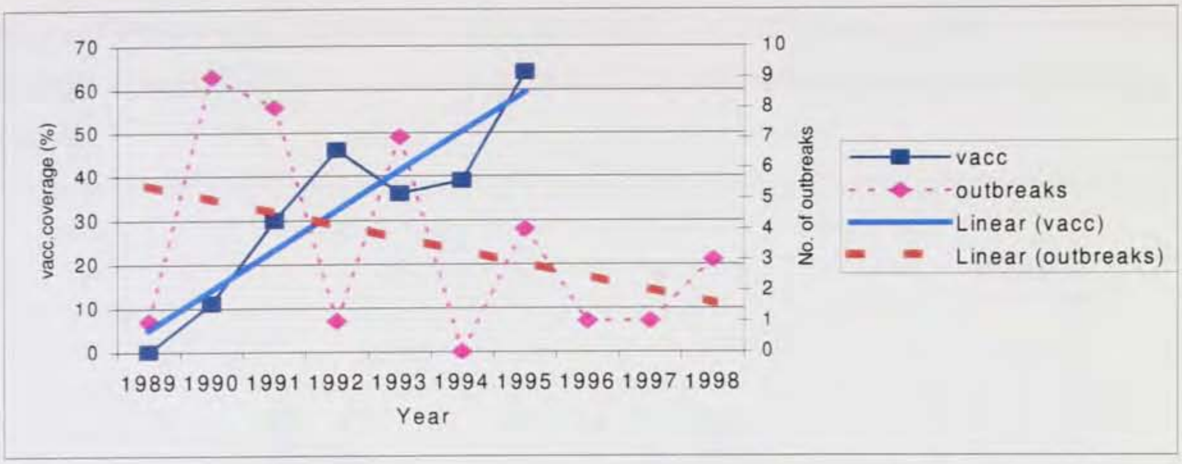


Figure 45: Relationship between vaccination and outbreaks in Narok district Kenya (newly infected), 1989-1995.

Apparently an intensification of the vaccination campaign in Narok district led to a decline in outbreaks (Fig. 45).

The countrywide trend indicates an increase in vaccination doses used with increase in outbreaks (Annex 20).

Monthly vaccination practice

The trend of monthly vaccination in the CBPP endemic districts of Turkana, Tanariver, and Marsabit is displayed in Fig. 46, Fig. 47 and Fig. 48, respectively, while that for newly infected districts of Kitui and Narok is presented in Fig. 49 and Fig. 50, respectively.

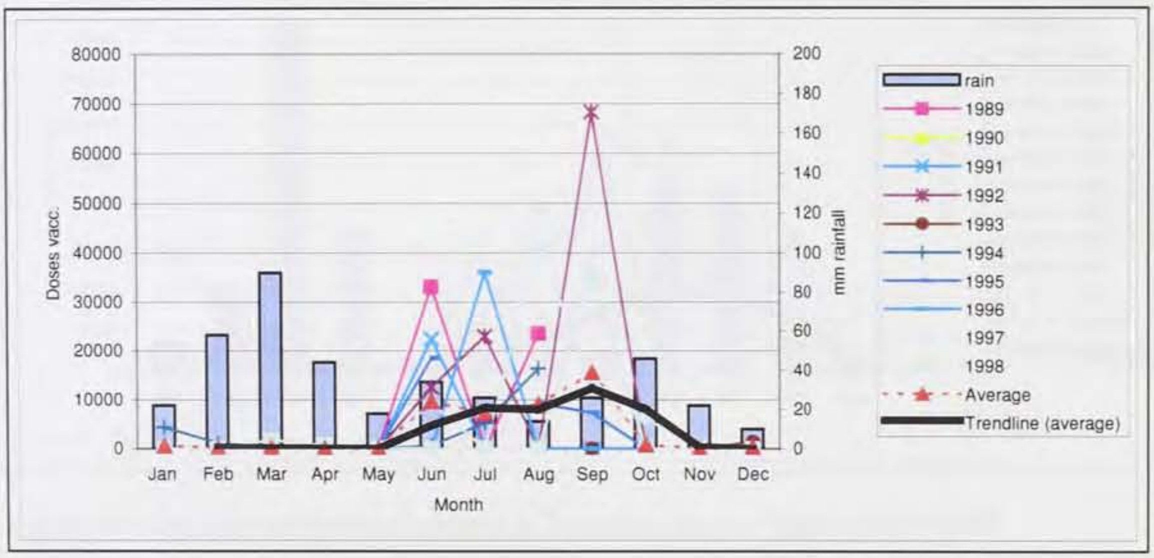


Figure 46: Monthly vaccination practice in Turkana district of Kenya, 1989-1998

There is at least some rainfall every month in Turkana district with more rains in the long rainy season from February to April, and no distinction between the dry and the short rainy season of September to November. Vaccination begins in the dry season, peaks in September and ends at the end of the short rains. Vaccination reached a monthly average of 15,000 doses (Fig. 46).

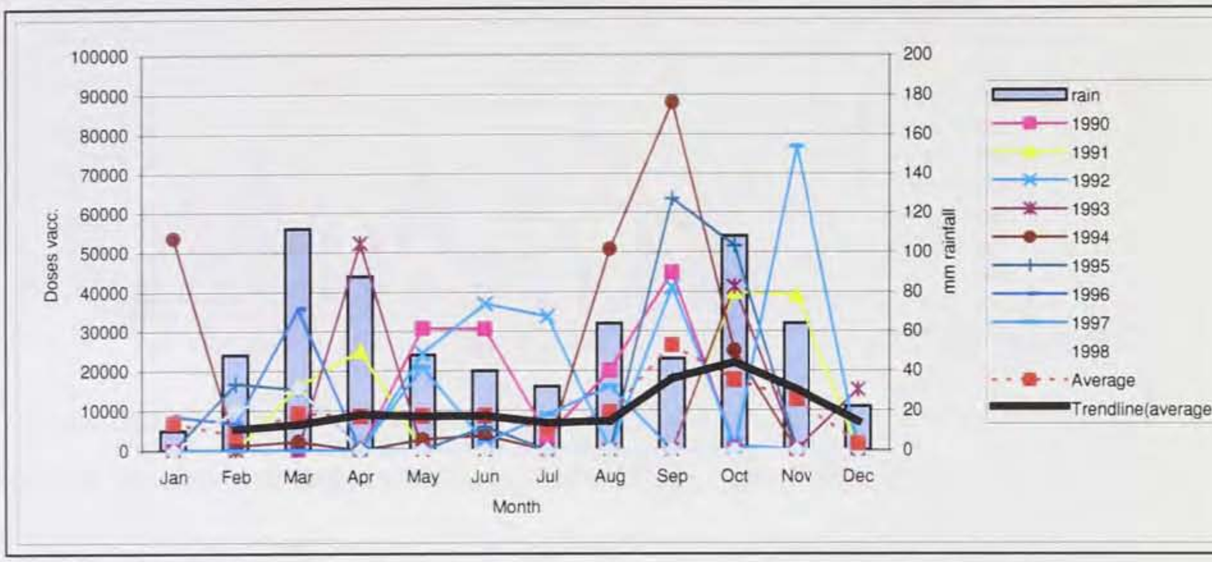


Figure 47: Monthly vaccination practice in Tanariver district of Kenya, 1990-1998

There is at least some rainfall every month in Tana river district with more rain in the long from February to May and the short rainy season from August to November. There is vaccination throughout the year with a peak in the short rainy season in October; a monthly average of 20,000 doses over the years investigated was achieved (Fig. 47).

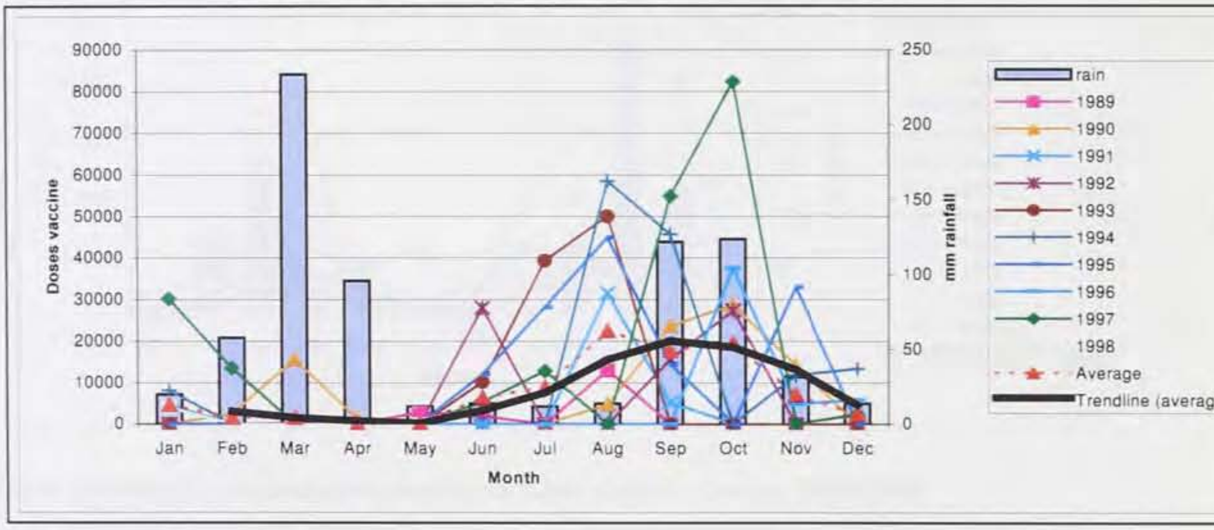


Figure 48: Monthly vaccination practice in Marsabit district, Kenya, 1989-1998

Rainfall in Marsabit district is bimodal with a long rainy season between February and April and a short dry season between September and November. Vaccination takes place during the dry and wet season from June to November peaking in August/September. The average monthly vaccination reached 20,000 doses (Fig. 48).

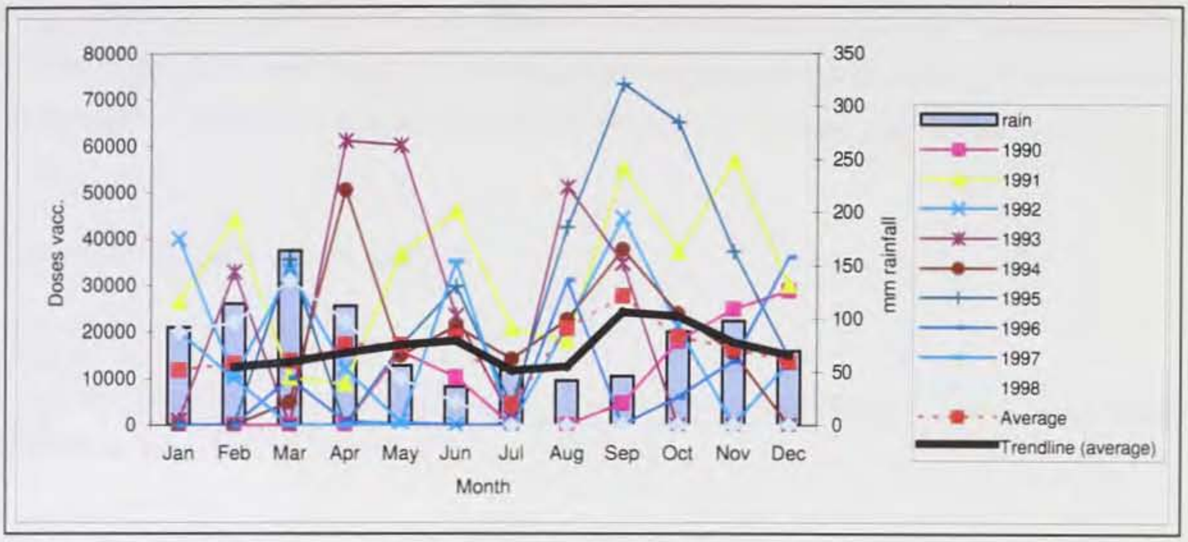


Figure 49: Monthly vaccination practice in Narok district, Kenya, 1990-1998

There is rainfall throughout the year in Narok district but mainly during the long rainy season (February to May) and in the short rainy season (September to November). Vaccinations were throughout the year but mainly from August to December with a peak in September. Average monthly vaccination reached 28,000 doses (Fig. 49).

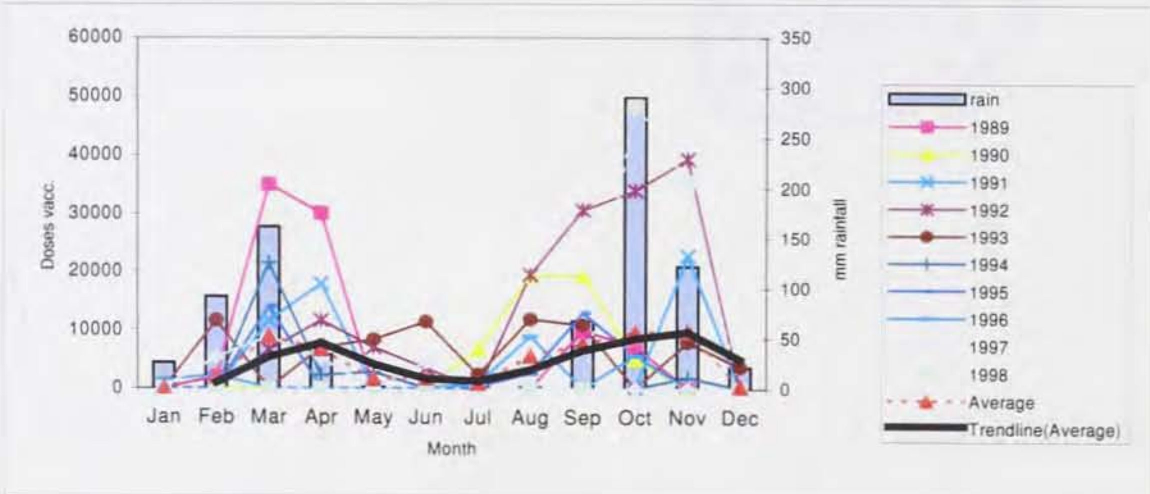


Figure 50: Monthly vaccination practice in Kitui district, Kenya, 1989-1998

Rainfall in Kitui district is bimodal with a long rainy season between February and April and a short dry season between September and November. Vaccination is also bimodal from February to June peaking in April, and resumes between August and November peaking in November.

Vaccination figures were higher during the short rains; average monthly vaccination figures reached 11,000 doses (Fig. 50).

Thus, in summary, CBPP vaccinations followed in most districts a distinct pattern beginning at the start of the short rainy season and ending at the beginning of the dry season. Districts with rain throughout the year vaccinated throughout the year with a major peak during the short rainy season.

4.4 Results of questionnaire analysis

4.4.1 Farmer questionnaire

166 farmer questionnaires were administered. Household and production systems parametesr are provided in Table 9.

Table 9: Descriptive household and production system data of Tanariver, Mwingi, Makueni, Narok, Kajiado, Nairobi, Thika and Kiambu districts, Kenya, 1999.

Parameter	Tanariver n=21	Mwingi n=24	Makueni n=25	Kajiado n=16	Narok n=22	Nairobi n=17	Thika n=19	Kiambu n=22
Person interviewed								
Head of family	100%	88%	88%	63%	72%	41%	84%	100%
Spouse		8%	8%		6%	29%	5%	
Other family member		4%	4%	19%	22%		5%	
Herdsman						12%		
Manager				6%		6%	5%	
Median family size	33 - pastoralists 12- mixed farmers	13	11	20	40	9	12	12
Education of family head								
None	69%	21%	8%	25%	56%	6%	11%	32%
Primary	12%	63%	48%	25%	22%	18%	42%	36%
Secondary	19%		36%	19%	17%	24%	32%	18%
Adult		16%		6%	6%	24%		
University				6%				
Major source of income								
Cattle keeping	73%	67%	48%	88%	86%	18%	74%	59%
Crop farming	20%	13%	20%				5%	18%
Employment	7%	17%	12%			24%		5%
Bussiness		4%	12%	6%		29%	16%	14%
Additional source of income								
Cattle keeping								
Sheep and goats	11%	33%	44%	13%		53%	21%	32%
Crop farming	58%	58%	20%	69%	32%	18%		18%
Employment	26%	88%	60%	38%	73%	24%	74%	64%
Business	5%		8%	13%	23%	6%		5%
		46%	4%	6%			11%	
Total herd sizes	1513	563	316	2289	4045	301	409	636
Median herd size	68 (10)	15	7	129	250	15	8	10
Production system								
Traditional pastoralism	48%			25%	32%			5%
Agropastoralism	52%				59%			
Mixed farming		96%	92%	13%	5%	6%		
Semizero grazing		4%	4%			6%		27%
Periurban			4%			12%		
Group ranch				50%	5%	35%	95%	
Commercial ranch				13%		12%	5%	59%
Zerograzing						29%		9%

Parameter	Tanariver n=21	Mwingi n=24	Makueni n=25	Kajiado n=16	Narok n=22	Nairobi n=17	Thika n=19	Kiambu n=22
Grazing								
Communal	86%	12%	12%	75%	100%	47%	84%	64%
Enclosed	14%	88%	76%	25%		29%	16%	14%
Zerograzing			4%			24%		14%
Semizerograzing			8%					
Roadside								5%
Movement								
Settled	71%	100%	100%	88%	95%	100%	100%	100%
Seminomadic	29%			12%				
Nomadic					5%			
Production								
Dairy			4%			59%	11%	27%
Beef	48%	63%	76%	50%	55%	41%	58%	32%
Dual	52%	37%	16%	50%	45%		26%	36%
Breed	Boran 100%	Zebu 100%	Zebu 80% Exotic 4% Cross 16%	Zebu 50% Exotic 6% Cross 44%	Zebu 100%	Zebu 18% Exotic 47% Cross 35%	Zebu 84% Exotic 11% Cross 5%	Zebu 59% Exotic 36% Cross 14%

Median herd size ( ) = among the mixed farmers

Among the pastoralist communities of Narok, Tanariver and Kajiado, family sizes were larger than in the other districts. Education o the farmer was found to be none or only at primary level among the pastoralist communities while they were more dependent on catt as a major source of income than farmers from other districts. The production system among the pastoralists was pimarily agropastoralism with a lower proportion practising traditional pastoralism. In the other districts, mixed farming and group ranching were more common. Grazing of cattle was mainly communal among the pastoralist communities but enclosed in other districts (Tab. 9).

Table 10: Disease ranking in the study districts according to CBPP district classification, 1999

District classification	Study District	Tryps	Anth.	CBPP	TBD	FMD	R/pest	Endopar.	BEF	Pneum.	LSD	Mastitis	BQ
Endemic	Tana river	1 (193)	2 (164)	3 (144)		4 (93)		5 (62)					
Newly Infected	Mwingi	5 (82)		2 (152)	3 (104)	1 (192)		4 (94)					
	Makueni			2 (180)	1 (202)	3 (112)			5 (59)				4 (76)
	Narok		5 (52)	2 (166)	1 (189)	3 (160)	4 (65)						
	Kajiado		4 (37)	3 (68)	1 (141)	2 (107)	5 (35)						
	Thika	4 (35)		1 (149)	2 (127)	3 (68)					5 (30)		
Clean	Nairobi			3 (35)	1 (131)					2 (40)	4 (23)	5 (17)	
	Kiambu			2 (128)	1 (202)	3 (100)	4 (48)				5 (35)		

Tryps=trypanosomosis CBPP= Contagious bovine pleuropneumonia TBDs = Tick borne diseases FMD= Foot and mouth disease BQ= Black quarter BEF = Bovine emphemeral fever LSD= Lumpy skin disease Endopar. = Endoparasites pneum.=pneumonia Anth. = Anthrax

( ) = total score

In Tana River district, which is an endemic district, CBPP was ranked 3rd after trypanosomosis and anthrax. In the newly infected and clean districts, Tick borne diseases were more important with CBPP and FMD interchanging second and third position in the respective districts (Tab.10)

Table 11: Farmers knowledge of CBPP in the study districts according to CBPP

district classification, Kenya,1999

District classification	District	Very good no. of farmers (in %)	Good no. of farmers (in %)	Fair no. of farmers (in %)	Poor no. of farmers (in %)	None no. of farmers (in %)
Endemic	Tanariver	4 (19%)	14 (67%)	3 (14%)		
Newly infected	Mwingi		12 (50%)	3 (13%)	4 (17%)	5 (21%)
	Thika	6 (32%)	8 (42%)	5 (26%)		
	Makueni	3 (12%)	10 (40%	12 (48%)		
	Kajiado	5 (31%)	6 (34%)	2 (13%)	1 (6%)	2 (13%)
	Narok	15 (68%)		1 (5%)	4 (18%)	2 (9%)
Clean	Nairobi	3 (18%)	2 (12%)	12 (71%)		
	Kiambu	8 (36%)	5 (23%)	1 (5%)	1 (5%)	2 (9%)
	Total	44 (27%)	57 (36%)	39 (24%)	10 (6%)	11 (7%)

The CBPP knowledge of farmers was mainly good to very good in the endemic and newly infected districts. Even in the clean districts considerable knowledge was registered. However, there was a small proportion of farmers who had poor or no knowledge at all of CBPP especially in the recently infected districts of Kajiado, Narok and Mwingi. Thika which is very recently infected indicated fair to very good knowledge of farmers (Table 11). The indigenous terminology for CBPP in the study districts is to be found in Annex 15.

Table 12: History of CBPP as reported by livestock keepers in the study districts,

Kenya, 1999

District	Farmers who experienced CBPP (in %)	≤ 1 year ago (in %)	2 years ago (in %)	3 years ago (in %)	4 years ago (in %)	≥ 5 years ago (in %)
Tanariver	19(90%)	2(11%)	1(5%)	6(32%)		10(53%)
Mwingi	17(71%)	5(21%)	1(4%)	3(13%)	1(4%)	7(29%)
Makueni	21(84%)	7(33%)	2(10%)	2(10%)	2(10%)	8(38%)
Kajiado	11(69%)	5(45%)	1(9%)			5(45%)
Narok	17(77%	7(41%)		4(24%)		6(35%)
Nairobi	5(29%)	2(40%)			2(40%)	1(20%)
Thika	12(63%)	4(33%)	7(58%)			1(8%)
Kiambu	19(86%)	3(16%)		1(5%)		15(79%)
All districts	121(73%)	35(29%)	12(10%)	16(13%)	5(4%)	53(44%)

CBPP was experienced by the livestock keepers in the study districts more in the past but also recently in the last year (Table 12).

Table 13: Age groups affected by CBPP as perceived/experienced by livestock keepers in the study districts, Kenya, 1999

District	< 2 years (% farmers)	>2 years (% farmers)	All age groups (% farmers)
Tanariver	1 (5%)	3 (16%)	14 (74%)
Mwingi	1 (6%)	12 (71%)	4 (24%)
Makueni		10 (48%)	8 (38%)
Kajiado		9 (82%)	2 (18%)
Narok	1 (6%)	7 (41%)	9 (53)
Nairobi		2 (40%)	1 (20%)
Thika	2 (17%)	1 (8%)	9 (75%)
Kiambu	1 (5%)	9 (47%)	7 (37%)
Total	6 (5%)	53 (44%)	54 (45%)

CBPP was experienced in all age groups but more in cattle over two years of age (Table 13).

Table 14: Economic losses associated with CBPP assessed and/or experienced by livestock keepers in the study districts, Kenya, 1999

District	Losses due to deaths (US $)	Average Losses per farmer per year(US $)
Tana River	60,000	600
Mwingi	36,423	304
Makueni	27,663	220
Kajiado	131,166	1,640
Narok	46,167	420
Nairobi	633	8
Thika	18,233	192
Kiambu	11,800	108
Total	332,085	3,492

Heavier losses were experienced in the Endemic and newly infected districts and more in the pastoralist communities of Tana River, Narok, and Kajiado (Table 14). The cost of CBPP vaccine is 0.03 US $ which is negligible compared to the loss incurred if an animal dies (i.e. not slaughtered). To make a more detailed comparison a profound economic analysis is required.

Table15: Ranking of risk factors associated with CBPP by livestock keepers in the study districts, Kenya, 1999

Risk factor	Tana River	Mwingi	Makueni	Narok	Kajiado	Nairobi	Thika	Kiambu
Purchased Animals	2	1	1	2	2	1	2	2
Communal Watering		3	2			3		
Communal Grazing			3	1	3		1	3
Movement of cattle	1	2	4	3	1	4	3	5
Proximity to trade routes			5	4	5	5		1
Ticks	3	5				2	4	
Cattle rustling								4
Contaminated water		4		5	4		5	

Cattle purchased from CBPP endemic districts were blamed for CBPP outbreaks, particularly those en-route for slaughter in Nairobi. Commu grazing and watering of cattle which is inevitable in pastoralist areas was indicated as an important risk factor. Movement of cattle from pastora areas in search of grazing during drought was indicated particularly in Tana River district where cattle congregate at the river delta and are joir by those from other districts especially Garissa which is also an endemic district. The newly infected districts are also under threat from th grazing cattle which do occassionally move there in the event of extreme drought (Table 15).

Table 16: Conventional treatment against CBPP and animal recovery in the study districts, Kenya, 1999

District	Administered conventional drug.	Mean recovery rate
Tanariver	Oxytetracyclines	40%
Mwingi	Oxytetracyclines	0-90%
	Penicillin/Streptomycin	30%
Makueni	Oxytetracyclines	0%
Kajiado	Oxytetracyclines	20-100%
	Penicillin/Streptomycin	20-100%
Narok	Oxytetracycline	70%
	Berenil, Novidium	0%
Nairobi	Oxytetracyclines	
	Penicillin/Streptomycin	
Thika	Penicillin/Streptomycin	0%
Kiambu	Oxytetracyclines	20%

Oxytetracyclines were widely used in attempts to treat CBPP. Farmers reported recovery rates of 0% to 100% (Table 16). However, the farmers indicated that the recovery is not complete as the disease subsides only to recurr at a later stage.

Table 17: Traditional treatment against CBPP as applied by livestock keepers in the study districts, Kenya, 1999

District	Treatment	Route of administration	Recovery rate
Tanariver	Lung of infected cattle	Intramascular	
	Coffee		
Mwingi	"Mua"	Oral	0%
	"Mukilifi" ("Mwarobaini")	Oral	0%
	"Muvua"	Oral	60%
	"Mukenea"	Oral	60%
	Salt	Oral	40%
Makueni	"Kiluma"	Oral	10%
	Goat skin and "Muvua vui"	Oral	10%
	"Muteta"	Oral	10%
	"Muswaa"	Oral	
	Tea leaves	Oral	
	Mwaitha	Oral	
	"Muva"	Oral	
	"Mithulu"	Oral	
Kajiado	"Kibuti"+ "Kalahu"+ "Sukuru"	Oral	60%
Narok	None		
Nairobi	Giraffe tree extract	Oral	
	"Wanga" tree extract	Oral	
Thika	"Muinu"		0%
Kiambu	None		

Only isolated farmers reported the use of traditional treatment in most districts except in the Makueni and Mwingi districts where almost every farmer interviewed reported some form of treatment. It is worth noting that the pastoralists of Narok and Kajiado reported virtually no traditional treatment (Tab.17).

Although both conventional (Table 16) and traditional treatment (Table 17) were attempted by some farmers, farmers and especially those in Maasailand believed that it is only vaccination that can result in the recovery of their cattle and often did not understand why cattle should be vaccinated when there are no outbreaks. Table 18 gives an overview of vaccination experience by the respondents of the questionnaire.

Table 18: CBPP vaccination experience of the livestock keepers interviewed in the study districts, Kenya, 1999

District	No. of farmers reporting	Last vaccination				Reasons for vaccination	Vaccinating personnel	Payment for vaccine
		≤ 1 yr	2 yrs	4 yrs	≥5 yrs			
Tanariver	21 (100%)	21 (100%				Routine, outbreak	Government personnel (100%)	No (100%)
Mwingi	23 (96%)	18 (78%)		5 (22%)		Routine	Government personnel (80%) Private veterinarian (10%)	No (91%) Yes (9%)
Makueni	19 (76%)	16 (84%)	2 (11%)		1 (5%)	Routine	Government personnel (100%)	No (100%)
Kajiado	14 (88%)	11 (76%)	2 (14%)		1 (7%)	Routine	Government personnel (100%)	No (100%)
Narok	20 (91%)	16 (80%)	2 (10%)	1 (5%)	1 (5%)	Routine, outbreak, rumour	Government personnel (100%)	No (80%) Yes (20%)
Nairobi	2 (12%)	1 (50%)			1 (50%)	Suspected outbreak	Government personnel (100%)	
Thika	17 (89%)	14 (82%)	3 (18%)			Routine outbreak Ring vaccination	CBAHW (18%) Government personnel (82%)	No (24%) Yes (76%)
Kiambu	0 (0%)							
Total	116 (70%)	97 (84%)	9 (8%)	6 (5%)	4(3%)			

Most of the farmers in most of the districts had their animals vaccinated in the last year by mainly government veterinary personnel (Table Although CBPP vaccination is free, some farmers in Mwingi, Narok and particularly in Thika claimed to have paid for the vaccination tho they were unable to establish whether the payment was specifically for the CBPP vaccine or for other vaccinations such as FMD usually d together with CBPP vaccination.

Table 19: Rumours of CBPP and action taken according to farmers interviewed in the study districts, Kenya, 1999

District	Farmers reporting	Location of rumour	Action taken by farmer				Action taken by veterinary personnel
			Report	Nothing	Traditional quarantine	investigation	
Tanariver	4 (19%)	Garsen	4 (100%)				Vaccination and Investigation
Mwingi	17 (71%)	Local	11 (65%)	6 (35%)			Vaccination and Investigation
Makueni	18 (72%)	Local Kajiado	17 (94%)	1 (6%)			Vaccination Investigation Sampling
Kajiado	11 (69%)	Local Tanzania	4 (36%)	6 (55%)		1 (9%)	Vaccination Investigation
Narok	15 (68%)	Local Tanzania	4 (27%)	10 (66%)	1 (7%)		Vaccination
Nairobi	3 (18%)	Local Machakos		3 (100%)			
Thika	1 (5%)	Local		1 (100%)			
Kiambu	6 (35%)	Local	1 (17%)	5 (83%)			Vaccination
Total	75(45%)		41(55%)	32(43%)	1(1%)	1(1%)	

Although rumours were not recorded officially by the respective districts, they were common and generated some action from the farmers and the veterinary personnel (Table 19). Farmers report, investigate or do traditional quarantine by isolating the suspected herds while veterinarians investigate, sample and in intensified rumours do vaccinate. This demonstrates that CBPP is taken serious by both the farmer and the veterinary personnel in the study districts.

Table 20: Further action taken against CBPP by farmer (n=121) in the study districts, Kenya, 1999

District	Treat	Report	Treat and report	Treat, report and sell	Treat and slaughter	nothing	Treat and trad. quar.	Treat, report and trad. quar	Report and slaughter	Report, slaughter and trad. quar.	Trad. Quar.
Tanariver	4	11	2								
Mwingi	1	6	9			1					
Makueni	16		3	1	1						
Kajiado		1	10	1							
Narok	2	2	9					1	1	1	1
Nairobi		2	3								
Thika		6	5								
Kiambu		12	2	1			6				
Total	23 (19.0%)	40 (33.1%)	43 (35.5%)	3 (2.4%)	1 (0.8%)	1 (0.8%)	6 (5%)	1 (0.8%)	1 (0.8%)	1 (0.8%)	1 (0.8%

Trad. = traditional quar.= quarantine

The most common action taken against CBPP by the farmers was combined treatment and reporting, reporting only and treatment only (Table 20).

Table 21: Action taken by veterinary personnel as reported by farmers in the study districts, Kenya, 1999

Action	Tana River	Mwingi	Makueni	Kajiado	Narok	Nairobi	Thika	Kiambu	Total
Vacc and scr				1					1
Vacc	10	3	7	3	10		2	2	37
Quar and scr				1					1
Samp	1			1					2
Slaug								2	2
Slaug, vacc and quar	1		1					1	3
Slaug, vacc quar and samp	1								1
Vacc and quar	3	4	6	1	3				17
Quar								1	1
Vacc and samp	1			1			1		3
Vacc, quar and scr				1				1	2
Vacc. Samp and scr				1					1
Vacc and slaug			1					1	2
Slaug and quar								1	1
Slaug and scr								1	1
Vacc and treat		1	1					1	1
Nothing			2				1		3
Treat	7		2			5	3	1	18
Slaug, vacc and scr							1		1
Vacc and scr							4		4
Slaug, vacc, quar and scr.					1				1
Slaug. Vacc, scr and samp			1						1

Vacc=vaccination scr. = Screening Samp.=sampling Quar.=quarantine Slaugh. = slaughter

Vaccination was the most common action taken by veterinary personnel followed by treatment and a combination of vaccination quarantine (Table 21).

Table 22: Personnel to whom disease is reported as described by the farmer in the study districts, Kenya, 1999

District	CBAHW/ Paraveterinary personnel	Veterinary office	Local administration	Traditional leader	Reasons for not reporting
Tanariver		84%			
Mwingi	26%	40%			Unavailability of vet. personnel
Makueni	17%	83%			
Kajiado		55%			Need to contact distant owner
Narok		14%	10%		-Lack of confidence in veterinary personnel -Unavailability of veterinary personnel -Long distance
Nairobi	100%				
Thika	33%	17%		17%	
Kiambu	11%	53%		5%	

Table 22 indicates that farmers reported CBPP more often to the veterinary office and animal health worker than to the local dministration and traditional leaders.

Table 23: Clinical signs of CBPP as reported by the farmers interviewed in the study districts, Kenya, 1999.

Clinical sign	No. of farmers reporting	Proportion %
Cough	114	81.4
Death	38	27.1
Emaciation	37	26.4
Starry coat	32	22.9
Anorexia	32	22.9
Laboured breathing	29	20.7
Salivation	20	14.3
Mucoid nasal discharge	15	10.7
Depression	13	9.3
Lacrimation	13	9.3
Diarrhoea	12	8.6
Bloat	9	6.4
Difficult gait	9	6.4
Fever	8	5.7
Weakness	7	5.0
Recumbency	4	2.9
Bad breath	3	2.1
Abortion	3	2.1
Arched back	3	2.1
Anaemia	3	2.1
Lagging behind	3	2.1
Swollen glands	3	2.1
Increased respiration	2	1.4
Elbows out	2	1.4
Falling on stress	1	0.7
Inflammed nostrils	1	0.7
Impaired vision	1	0.7
Constipation	1	0.7
rembling	1	0.7
Decreased milk yield	1	0.7
Dehydration	1	0.7
Restlessness	1	0.7
Insiduous	1	0.7

Table 23 indicates that cough, death, emaciation, starry coat, annorexia and laboured breathing were the most commonly observed signs. Clinical signs atypical of CBPP such as swollen glands, anaemia and constipation were also reported by the livestock keepers interviewed.

Table 24: Post-mortem lesions in CBPP as reported by farmers in the study districts, Kenya, 1999

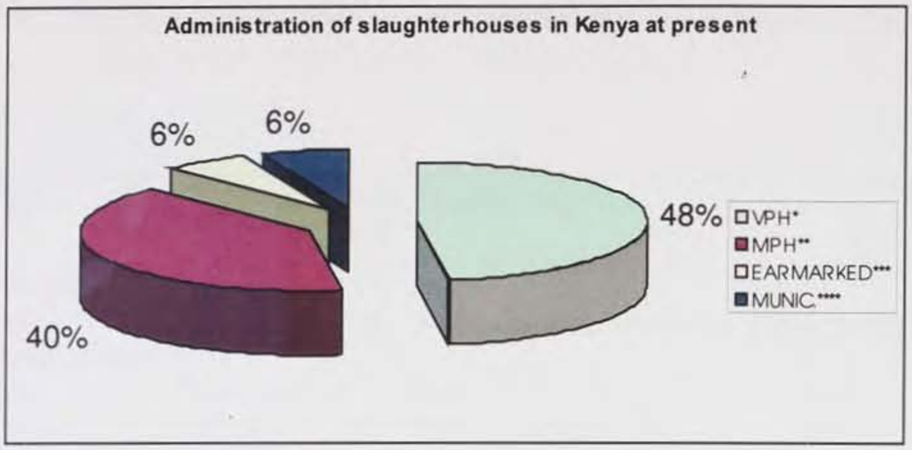
Post-mortem lesions	No. of farmers reporting	Proportion %
Rib/lung adhesions	56	40.0
Necrotic lungs*	50	35.7
Fibrin in chest cavity	32	22.9
Anaemic lungs	23	16.4
Enlarged lungs	21	15.0
Pleural fluid	19	13.6
Enlarged gall bladder	11	7.9
Fragile lungs	10	7.1
Frothy lungs	8	5.7
Lung haemorrhages / petechiae/thrombosis	7	5.0
Sequestra/abscess	7	5.0
Marbled lungs	6	4.3
Frothy trachea	5	3.6
Enlarged liver	4	2.9
Enlarged spleen	3	2.1
Ascites	3	2.1
Lung hepatization	2	1.4
Cooked lung appearance	2	1.4
Enlarged heart	2	1.4
Necrotic liver	2	1.4
Pericardial fluid	2	1.4
Enlarged kidney	1	0.7
Liquefied bone marrow	1	0.7

* 8 (16%) of the farmers indicated that it was unilateral

Table 24 indicates rib/lung adhesions, necrotic lungs (sometimes unilateral), fibrin in the chest cavity, anaemia of lungs, enlarged lungs, and pleural fluid to be the most common post-mortem lesions observed by farmers. Post-mortem lesions atypical for CBPP such as enlarged gall bladder were also reported.

4.4.2 Slaughterhouse questionnaire

The results of questionnaires administered to 12 slaughterhouse personnel are presented in Fig. 47, Table 25 and 26 and Annex 12a, 12b and 12c.



* Veterinary public health

** Medical public health

*** earmarked for taking over by VPH

**** Veterinary public health only in municipalities

Figure 51: Classification of slaughterhouses in Kenya at present.

Classification of slaughterhouse administration by district is to be found in Annex 12. Fig. 47 indicates that only 48% of slaughterhouses are under VPH. After taking over of another 6%, VPH will operate in 54% of the districts. Annex 12a , 12b and 12c indicate that VPH operates in only one of the CBPP endemic districts but in 50% of the newly infected districts and 50% of the clean districts.

Table 25: Origin of cattle and daily kill of selected slaughterhouses in the study districts, Kenya, 1999

Place	District	Daily kill	Origin of cattle
Kitengela	Kajiado	10	local
Thika Municipality	Thika	20	local, Garissa, Machakos, Kitui, Nyandarua, Kwale, Kilifi
Hola	Tanariver	3	local
Bisil	Kajiado	40	local, Tanzania
Dagoretti	Kiambu	400	Narok, Kajiado, Nakuru,T/nzoia, U/gishu, Baringo, Kuria, Kisii, W/pokot, Turkana, Samburu, Machakos, Kitui, Laikipia
Hurlingham	Nairobi	7	Laikipia, Machakos, Nakuru
Nyonjoro	Nairobi	15	Dagoretti
Kayole	Nairobi	40	local,N.E.P, Kuria, Kitui, Mwingi, Machakos, Laikipia
Dandora	Nairobi	100	N.E.P, Kuria, Samburu, Laikipia, Turkana, Kajiado, T/river, Kiambu, Nairobi
Wote	Makueni	5	local, Emali
Migwani	Mwingi	1	local, Garissa
Mwingi	Mwingi	6	local, Garissa

N.E.P = North- Eastern Province

In the large slaughterhouses of Kiambu and Nairobi cattle arrived by vehicle from several districts most of them classified as endemic or recently infected. The smaller slaughterhouses received cattle on hoof and also from endemic districts although most of the cattle were local (Table 25). Only the slaughterhouses of Nairobi and Kiambu had the official mandate from the Veterinary Department to slaughter cattle from CBPP infected districts.

Table 26: Mode of movement of cattle to selected slaughterhouses in the study districts, Kenya, 1999.

Slaughterhouse	On hoof (in %)	By vehicle (in %)	Movement permits
Kitengela	99	1	No
Thika municipality	90	10	Yes
Hola	100	0	No
Bisil	100	0	No
Dagoretti	5	95	Yes
Hurlingham	0	100	Yes
Nyonjoro	99	1	No
Kayole	1	99	No
Dandora	1	99	Yes
Wote	100	0	No
Migwani	100	0	Yes
Mwingi	100	0	No

For cattle arriving by vehicle without permits (Table 26) action taken includes reporting to the District Veterinary Officer of the district of origin, confiscation of the cattle, keeping records while slaughtering anyway to avoid the risk of sending back cattle which bear the chance of being infected.

Arrival of livestock at the slaughterhouses is usually direct, except at the Kayole and Nyonjoro slaughterhouses where cattle arrive first at the Dandora and Dagoretti slaughterhouses, respectively.

Unusual increases in slaughter cattle numbers could not be associated with disease outbreaks but festivities and at times when farmers need to sell their cattle to gather monies for school fees.

67% of the slaughterhouses in the area covered did not have a holding ground while Dagoretti slaughter complex has one holding ground for four slaughterhouses.In the past the Dagoretti slaughter complex had a communal holding ground from which cattle were moved to the slaughterhouses. Dandora slaughterhouse has a holding ground too large to serve any useful purpose (up to 1000 acres) as slaughterhouse cattle do definitely come into contact with local cattle as substantiated by farmers interviwed.

Ante-mortem inspection is carried out in all slaughterhouses mainly by the meat inspectors and by the veterinarians in charge. Only the slaughterhouse in Wote indicated that it did ever encounter a

CBPP case at ante-mortem while 6 slaughterhouses (Thika, Bisil, Kayole, Dandora, Wote and Mwingi) encountered CBPP cases at slaughter in the last 3 years. The action taken included notification of the area veterinarian, sampling for disease confirmation and simple condemnation of the organs of the thoracic cavity.

While Dagoretti slaughterhouse complex was described as having an official mandate to slaughter cattle from CBPP districts, theThika Municipality slaughterhouse was described as having only an unofficial mandate. Dandora and Mwingi slaughterhouses were not aware of any such definition of slaughterhouses. The other slaughterhouses were described as having no such mandate.

25% of the slaughterhouse personnel reported to have heard rumours of CBPP upon which they reported to the veterinary office or did some investigation; however, half of them did not take any action.

All slaughterhouse personnel expressed that the slaughterhouses have an important role to play in CBPP control in as far as sampling is concerned but felt that the disease should be controlled at the district of origin before thearrival of cattle at the slaughterhouse. One slaughterhouse staff in Tanariver district where meat inspection is under the Ministry of Health could not understand the role of the slaughterhouse in CBPP control as his major interest is in zoonotic diseases. Attempts to administer a questionnaire to slaughterhouse personnel in Narok district, which is also under the Ministry of Health, were fruitless.

4.4.3 Veterinarian questionnaire

14 questionnaires were administered to veterinarians in 8 districts. The results of questionnaire analysis are presented in Tables 27 to 30.

Table 27: Production systems as described by veterinarians in the study districts, Kenya, 1999

District	Traditional pastoralist herds (%)	Mixed farms (%)	Ranches (%)	Zerograzing (%)
Makueni		89	10	1
Thika		50	20	30
Tanariver	100			
Kajiado	60	15	10	5
Kiambu	10	60	30	
Nairobi	10	30		60
Narok	90	9		1
Mwingi	0	99	0	1

This classification (Tab. 27) generally agreed with what was observed during farmer questionnaire administration that traditional pastoralist herds were mainly found in Kajiado, Narok and Tana River although there was no indication of agropastoralism displacing traditional pastoralism. Mixed farming, and zerograzing were described to prevail in the other districts.

Table 28: Disease ranking according to the veterinarians in the study districts, Kenya, 1999

District classification	Study district	Tryps	Anthrax	CBPP	TBDs	FMD	Endopar.	BQ	Mastitis	Nutr. problems	Pneum.	LSD
Endemic	Tana River	2	3	1			4					
Newly infected	Mwingi	2		4	1		3					
	Makueni	1		5	2	3		4				
	Narok	3		5	1	2	4					
	Kajiado			5	1	2	3	4				
	Thika	4	3	5	2	1						
Clean	Nairobi				1	2	3			5		4
	Kiambu		5		1				3		2	4

Tryps=trypanosomosis CBPP= Contagious bovine pleuropneumonia TBDs = Tick borne diseases FMD= Foot and mouth disease BQ= Black quarter LSD= Lumpy skin disease Nutri. = Nutritional Pneum. =pneumoniaEndopar. = Endoparasites

Except in Tana River district (endemic) where CBPP was ranked as the most important disease, CBPP took 4th and 5th position in the other districts. TBDs and FMD interchanged 1st and 2nd position in the respective districts (Tab. 28). This is in contrast to the ranking by farmers who ranked CBPP mainly in 2nd position.

Table 29: Reporting of CBPP by farmers to veterinarians and presence of CBPP according to veterinarians in the study districts, Kenya, 1999

District	Presence of CBPP	Reporting of CBPP
Makueni	yes	no
Thika	yes	no
Tanariver	yes	yes
kajiado	yes	yes
Kiambu (Limuru)	yes	no
Kiambu (Kikuyu)	yes	yes
Nairobi (Central)	nes	no
Nairobi (Embakasi)	yes	yes
Nairobi (Langata)	no	no
Nairobi (Kasarani)	no	no
Narok	yes	yes
Mwingi	yes	no

While CBPP was reported to be present in Thika, Makueni, Kiambu and Mwingi, the veterinarians indicated that the farmers did not report the disease to them often (Table 29). Reasons are that some farmers were not aware of the disease while others preferred to report the disease to CBAHWs for fear of high charges by veterinarians. Sometimes livestock keepers prefer to report the disease first to local leaders as they fear reporting for the consequences such as quarantine and slaughter. 60% of the time CBPP is reported using the local name while 30% of the time it is reported only as a respiratory disease or as disease following introduction of new cattle or a disease following the movement of cattle from elsewhere.

Private veterinarians, CBAHWs and non-governmental organisations are also involved in disease control but only the CBAHWs and occassionally the private veterinarians report the disease to the field veterinarians.

Table 30: Ranking of risk factors associated with CBPP as described by veterinarians in the study districts, Kenya, 1999.

Risk factor	T/river	Mwingi	Makueni	Narok	Kajiado	Nairobi	Thika	Kiambu
Purchased Animals	1	2	1	2	1	1	2	1
Communal Grazing	3			3	3			2
Movement of cattle	2	3	2	4	2		1	3
Proximity to trade routes		1		1			3	
Lack of vaccination				5				

As the interviewed farmers, veterinarians also ranked the purchase of cattle from CBPP districts (Table 30) as the most important factor. Proximity to trade routes and cattle movement mainly from endemic districts were indicated as more important in Mwingi Narok.

While the other district veterinarians reported outbreaks in their districts, Nairobi and Mwingi district veterinarians reported sporadic cases. Outbreaks occured in the last two years (1997 and 1998) or more than five years ago as also indicated by the farmer

Table 31: Population at risk and mortalities as recorded during CBPP outbreaks by veterinarians in the study districts, Kenya, 1999

District	Year	Population at risk	Deaths	Mortality rate (%)
Makueni	1992	70,000	21000	30
Thika	1997	800	100	13
Kajiado	1998	14,000	300	2
Kiambu	1992	4,000		0
Narok	1998	1,000	8	1

Higher mortality was recorded in Makueni and Thika (Table 31) which are more recently infected districts (less than 10 years) than Kajiado, Kiambu and Narok which had recorded outbreaks in 1987, 1988 and 1989.Vaccinations were reported to be regular and routine in Makueni, Tanariver district, Narok and Mwingi while Thika, Kajiado and Kiambu vaccinated only in the event of an outbreak. Makueni and Nairobi vaccinated in the event of influx of cattle particularly from Kajiado district.

While field veterinarians reported to have received rumours of CBPP in Makueni, Tanariver, Kajiado, Nairobi and Narok, no rumour records existed in the other districts. Action against this rumours was,however, taken which included investigation, sampling, vaccination and notification of the District Veterinary Officer.

Except district veterinarians in Tanariver and Kajiado districts, no other district veterinarians received CBPP reports from the slaughterhouses.

4.4.4 Paraveterinary personnel questionnaire

The results of the questionnaire analysis are indicated in Tables 32 to 35.

Table 32: Disease ranking by paraveterinary staff in the study districts, Kenya, 1999.

District classification	Study district	Tryps	Anthrax	CBPP	TBDs	FMD	Endopar.	BQ	Haem. Sept.	Nutr. problems	Pneum.	LSD
Endemic	Tana River	1			2						3	
Newly infected	Mwingi	2		5	1		3				4	
	Makueni	2		5	1				4		3	
	Narok			3	1	2	4			5		
	Kajiado			4	1	2		3				
	Thika	2	3	4	1	5						
Clean	Nairobi			4	1	3					2	
	Kiambu			4	1						3	2

Tryps=trypanosomosis CBPP= Contagious bovine pleuropneumonia TBDs = Tick borne diseases FMD= Foot and mouth disease BQ= Black quarter

LSD= Lumpy skin disease

Endopar. = Endoparasites Pneum=Pneumonia Nutr. =nutritional Haem.Sept = haemorrhagic septicaemia.

In agreement with the veterinarians interviewed, CBPP was ranked 4th and 5th (Table 32) in all districts but in Tanariver there was disagreement in that the paraveterinary staff did not rank CBPP as an important disease while it was indicated as the most important disease by the veterinarian. Tick borne diseases were recorded to be the most important diseases there and in agreement with the veterinarians, trypanosomosis was important in Tanariver, Mwingi and Thika. The ranking of CBPP by paraveterinary personnel differed from that by farmers who ranked it second in most districts.

In Karen, Nairobi, nutritional problems replaced pneumonia whereas LSD replaced CBPP in importance whereas in Kasarani, Nairobi, mastitis replaced pneumonia and footrot replaced CBPP.

Table 33: Reasons for farmer awareness of CBPP as perceived by the paraveterinary personnel in the study districts, Kenya, 1999

District	Reasons
Tana river	Disease present
	Extension service
Mwingi	Disease present
	Neibouring CBPP area
	Extension service
Makueni	Disease present
	Farmer self education
Narok	Disease present
Kajiado	Disease present
	Farmer self education
Nairobi	Disease present
Thika	Disease present
	Extension service
Kiambu	Disease present

The good CBPP knowledge of the farmers recorded in the farmer questionnaire can the be linked to the farmers awareness of the disease due to its presence in the respective or neighbouring districts and subsequent farmer self education. However, extension service was important in creating CBPP awareness (Table 33).

Farmers were not aware of the disease in Limuru division of Kiambu district because the disease is not common, and in Langata division of Nairobi district because it is non existent.

While farmers report CBPP to the paraveterinary personnel in Mwingi, Thika, Tanariver, Kajiado, Kiambu, Nairobi (Embakasi) and Narok, they do not report to the AHAs in Makueni, Kiambu (Ndeiya) and Thika. When farmers do not report to the paraveterinary personnel they report instead to the veterinary office and to the local administration .

Table 34: Reasons for not reporting CBPP in order of importance according to paraveterinary personnel in Mwingi, Kajiado, Thika, Kiambu and Nairobi, 1999

District	Reasons
Mwingi	Fear of reporting Not necessary Long distance
Kajiado	Fear of reporting Long distance Lack of proper identification of the disease Lack of confidence in the veterinary service
Nairobi	Fear of reporting Need to contact distant owner Farmers report to private veterinarians who do not report to the veterinary office
Thika	Lack of transport Long distance Impassable roads during bad weather Need to contact distant owner
Kiambu	Fear of reporting Long distance Not necessary Need to contact distant owner

The reasons were comparable to those reported by the farmers and are common to virtually all the districts in which the paraveterinary personnel indicated no reporting of CBPP by the farmers (Table 34).

The knowledge of CBPP was found to be very good in 11(61%) of the paraveterinary personnel and good in 7(39%) of them.

Except in Nairobi district paraveterinary personnel in all other districts had had an experience with CBPP in the last five years which agrees with the veterinarian and farmer reports.

Table 35: Risk factors associated with CBPP outbreaks as described by paraveterinary personnel in the study districts, Kenya, 1999

Risk factor	Tana River	Mwingi	Makueni	Narok	Kajiado	Nairobi	Thika	Kiambu
Purchased animals		1	1	2	1		3	1
Communal grazing				3	4	2		5
Movement of cattle	1	2	2	4	2	1	2	2
Proximity to trade routes				1	3		1	4
Communal watering								3
Lack of vaccination		3		5				

In agreement with the farmers and the veterinarians interviewed the paraveterinary personnel indicated purchase of cattle from endemic districts as the most important risk factor. Movement of cattle particularly into Tana River was an important factor while in Narok and Thika proximity to trade routes was more important (Table 35).

Constraints in CBPP control

The following constraints in CBPP control were derived from district reports and stated in the questionnaires:

1. Lack of CBPP vaccines: while over five million cattle are eligible for vaccination, barely two million doses of CBPP vaccine have been released annually.
2. Allocations of funds particularly for transport and field operations have been insufficient every year, hence resulting in the irregularity and sometimes failure of vaccination campaigns and screening.
3. Breakdown of vehicles and lack of adequate equipment for vaccination and screening.
4. Lack of cooperation from farmers particularly in failing to present their cattle for vaccination. These farmers believe that cattle should be vaccinated only in the event of an outbreak as vaccination against CBPP is believed to be a cure rather than a preventive measure. The adverse reactions of vaccines such as sloughing off of tails furthermore discourages farmers from presenting their cattle for vaccination. There is also resistance to vaccination especially when the body condition of the animals is poor fearing that the animals will die. Some believe that vaccination leads to contamination of the milk which may affect humans who consume it. Farmers who use cattle for ploughing will not present their cattle for vaccination during the planting season and calves in general are usually not presented for vaccinations usually due to problems of walking them to the vaccination sites.
5. Banditry and rustling of infected cattle especially when cattle are at holding grounds awaiting transportation to slaughter.
6. Movement of cattle without movement permits.
7. Illegal vaccination of cattle following outbreaks in non-endemic districts.
8. Drought leading to migration of cattle to distant districts and sometimes across national borders without prior vaccination.
9. Lack of adequate communication channels for swift reporting by farmers and field staff.
10. Fear of cost of vaccination. CBPP vaccination is free but it is carried out at the same time with other vaccinations such as FMD vaccination for which the farmer has to pay.
11. Fear of reporting disease due to fear of cost of treatment and consequences of vaccination, screening and quarantine.
12. Lack of full awareness of CBPP by the farmers and often confusion of the disease with other diseases even by trained personnel.

5.0 DISCUSSION

Upon questionnaire administration in the study area it was reaffirmed that cattle keeping constitutes a major source of income and an important money bank.

Production systems are changing from traditional pastoralism to agropastoralism and new types are becoming evident among the farming communities to accommodate cattle keeping and, thus, utilising best farm residues to better cater for the family's food needs and to generate additional income. Mixed farming and semizerograzing are thus becoming more common among the farming communities in Kenya.

Communal grazing continues among the pastoralist communities and communal watering is inevitable which offers excellent opportunities for the continued spread of CBPP (Mlengeya, 1995). Pastoralist communities are becoming more settled rather than nomadic which could mean as it is stated by Provost et al. 1987. that "CBPP would disappear from Africa if nomadism ceases". Production among the communities in the study area oscillated between beef and dual purpose; however, local cattle breeds are still the most common option. Keeping of exotic cattle is mainly favoured by the farming and zerograzing communities of Nairobi, Thika and Kiambu.

Outbreaks and their relationship to movement

CBPP which up to 1989 was confined to the endemic areas, is now seen to appear in areas which were considered clean or at high risk, and even in low risk areas. An alarming picture is that about 70% of the outbreaks observed in the last ten years have been experienced in districts theoretically considered as clean. This has led to the re-zoning of the country into CBPP endemic districts, into the CBPP newly infected districts and the clean districts (Annex 1b).

Through a retrospective study using passive data from the Veterinary Department of the Kenya Ministry of Agriculture and through an active data collection by means of questionnaires, possible causes of and contributing factors to the outbreaks were determined. From the results obtained these outbreaks can be attributed to movement of cattle in one way or other in considering the following:

- In earlier years cattle could move out of a CBPP endemic region only after passing three clear CFT tests, a control measure that has worked well in Italy and Portugal (Egwu et al., 1996). But what has been observed in this study is that the percentage of cattle screened before movement dropped from 45% in 1989 to barely 2% in 1998 implying that now almost all cattle are moved without being tested. For CBPP whose clinical signs, especially in the chronic stage, are not quite apparent it is not desirable to certify movement of cattle only on the basis of the absence of clinical signs. The absence of cattle testing before being moved out of a CBPP endemic region bears a high risk, and thus, can be the reason for outbreaks on ranches and farms in clean districts purchasing cattle from CBPP endemic districts for the purpose of fattening and breeding.

- Cattle for slaughter from CBPP endemic districts were up to 1987 allowed to move only to The Kenya Meat Commission slaughterhouses in Athiriver and Mombasa after being tested in approved holding grounds. Following the closure of these slaughterhouses, farmers and pastoralists had to find other markets for their cattle. Inspite of the fact that the Kenya Veterinary Department mandated other slaughterhouses (Dagoretti in Kiambu and Dandora in Nairobi) to handle these cattle, these slaughterhouses could not effectively deal with these cattle leading to cattle grazing on surrounding farms awaiting slaughter. Some stock-traders looked for alternative markets in non-mandated slaughterhouses or even on farms. This could explain some of the outbreaks in Embakasi in Nairobi, Kiambu and Thika districts.

- Cattle arriving at slaughterhouses are supposed to remain at the slaughterhouse holding grounds. This study, however, revealed that the Dandora slaughterhouse has a holding ground too large (about 1000 acres) to serve any useful purpose; as it borders farms cattle from both sides mix during grazing thus, allowing the transmission of the disease. At Dagoretti slaughterhouse cattle trekked from the slaughterhouse to the neighbouring Nyonjoro slaughterhouse provide a loophole through which cattle can disappear into the neighbouring farms. This could explain some of the outbreaks in Kiambu, Narok and Kajiado districts.

- Following civil disturbances in Somalia in 1989/90, Somalis entered Kenya through Garissa and even arrived in Nairobi to find a market for their cattle. This has been sustantiated further by the upsurge of cattle from Garissa arriving at the Dagoretti slaughterhouse during these years. A survey by the Veterinary Department in 1998 indicated that 40-50% of cattle at the Garissa market are from Somalia. These cattle were originally destined for slaughter but ended up with pastoralist herds in Narok, Kajiado, possibly Kiambu and the Coast province, especially Kilifi district which could well explain the outbreaks in these districts.

- Slaughter cattle mainly originated from CBPP infected districts. Indeed, 45% of the cattle moved for slaughter between 1989 and 1998 were from endemic districts while a further 44% were from CBPP newly infected districts. These cattle transit through clean districts as previously observed by Kane (1975) thus posing a high CBPP risk on the clean districts. Rarely are cattle arriving at the Dagoretti complex with unknown origin (up to 2.14%). These cattle arrived mainly by vehicle, and over half the time they are with permits indicating that the "unknown origin" status could be due to the failure to indicate the district of origin in the permit.

The tendency of cattle taking too long to arrive at the slaughterhouse points again to poor movement control.

- Though a high percentage of cattle destined for the slaughterhouse does eventually arrive, it is still worrying that not all cattle do. While it is understood that cattle may indeed die on transit, the more dangerous practice among stock traders to offload and sell cattle prior to their final destination might also explain why some consignments take too long on transit.. Farmers along the stock routes upon questionnaire administration substantiate this. Indeed cattle from Garissa en-route to Kiambu and Nairobi are offloaded at Mwingi and Thika, cattle from Tanariver are offloaded at Bangale and disappear into Kitui and eventually into Muranga and Kirinyaga districts. Cattle from Isiolo find markets in Embu and it is no wonder that these districts have been recently infected with CBPP.

- Transhumant cattle in search of water and grazing traversed epidemiological, ethnic, district and national and sometimes even natural boundaries. Thus, to impose movement control on cattle particularly during drought is difficult as contact rate of infected with non-infected cattle increases. As a result of this practice CBPP had persisted in the endemic regions and can be blamed for outbreaks in Nyandarua, Nakuru, Thika, Kiambu, Nairobi districts as well as for the spread from the original focus at Naroosura in Narok district to the entire district as well as to the neighbouring Transmara district.

- Cattle traders as also indicated by Egwu *et al.* (1996) may be responsible for the spread of CBPP. In Kenya, the predominant movement is from the sparsely populated to the densely populated areas. At the first hint of an outbreak or a rumour, villagers dispose of their animals to traders. This phenomenon can be blamed for the continued outbreaks of CBPP in Narok since 1990. An interesting observation was the upsurge of cattle arriving from Kuria district at the Dagoretti slaughter complex following rinderpest outbreaks in Southern Kajiado and Tanzania. Kuria district is a notorious entry point for ex -Tanzanian cattle into Kenya and, thus similar influxes are likely to occur in the event of a CBPP outbreak.

- Cattle rustling is quite common among the pastoralists and the bordering communities. Particularly in Kiambu district which borders the pastoralist areas of the Kajiado district, cattle rustling has been blamed for sporadic outbreaks of the disease dating back to the 70s (Kariuki, 1971) and especially as rustled cattle when recovered are returned to their owners.

- The Kenya Veterinary Department recommends that cattle from CBPP infected areas are moved by vehicle rather than on hoof. While this is adhered to in most districts, the recently infected Kajiado district still remains a problem area in this respect. The study of movement of cattle into Dagoretti complex indicated that the mode of movement has changed over the years: in the last five years over 80% of cattle are moved by vehicle compared to 60% between 1989 and 1994. The remaining less than 20% of cattle moved on hoof are from the neighbouring Kajiado district which is a CBPP newly infected district posing a threat to the cattle in the areas where these cattle trek through; and it is no wonder that CBPP has been reported in the Ndeiya location of Kiambu district possibly following Kajiado cattle movement on hoof. Further, all cattle moving for slaughter must do so with a valid movement permit. Kajiado is also a problem district in this respect in that of the observed 13% of cattle that moved without permits, 90% were from Kajiado. It was impressive to note that when stringent movement control was imposed in Kajiado district in 1997 following the outbreak of rinderpest during that year, cattle moving without permits declined to almost zero.

Farmers confirmed findings from district reports on the risk factors mentioned and added proximity to trade routes as a further risk factor especially in districts where trade cattle are still transported on hoof, either to the local markets or to loading areas when transported to far districts.

Rumours of CBPP were reported especially in Mwingi, Makueni, Kajiado and Narok districts and farmers often report to the veterinary office, carry out traditional quarantine or an investigation themselves. Veterinary personnel usually vaccinated cattle following rumours, but they also carried out investigations and, occassionally, sampled animals for laboratory investigation. Rumours are, however, not recorded and it is therefore difficult to establish whether there were any "background" cases before an actual outbreak occured.

In Kenya, outbreaks of CBPP appeared to be more common during the dry season than during the wet season. This agrees with the observations of Nwanta and Umoh (1992) but is contrary to Turner (1959) who stated that dry climate diminishes the risk of spread. In fact in Kenya cattle are more under stress of starvation, thirst, and movement over long distances during the dry season. The congregation of cattle from different epidemiological zones at watering points and at the available grazing land during the dry season could also explain this seasonality. A slight increase in outbreaks is, however, observed at the onset of the long rains and during the short rains which agrees with the report of Dennis (1986) that the change in temperature and relative humidity leads to a change in thesurvival of pathogens with a decrease in host resistance for respiratory diseases.

Outbreaks were confirmed mainly by the laboratory CFT, the field CFT or a combination of the two. Confirmation by AGID is relatively easy to perform (Ameh *et al*., 1995). However, the submission of samples for AGID to the laboratories in Kenya was low and was based only on cattle slaughtered as a consequence of a positive field CFT diagnosis. It was rare that the AGID alone was used to confirm CBPP cases. The laboratory CFT detects 74% of infected cattle (Bashiruddin et al., 1994) while the field CFT detects only 40% (Scudamore, 1975). Particular attention should thus be paid to a herd with even one positive case as this can be an indication of the presence of more cases in the herd, or even more herds infected. This is especially so as the field CFT is often applied to suspected and in-contact herds. The fact that positives are detected at screening before movement (Kane,1975) suggests a possibility that some of the outbreaks in endemic districts were not reported, a fact also observed in Nigeria by Ameh *et al*. (1995) or that vaccinated cattle reacted false positive. Another possibility is that continued vaccination had lead to a situation where clinical disease is no longer reported by the stock owners (Kane, 1975).

The economic loses associated with CBPP have been listed by Mlengeya (1995) and Egwu *et al.* (1996) in excess of one million dollars in terms of deaths in Tanzania in five years and in excess of 1.5 million dollars in direct losses in Africa in 1991. As lack of data on economic impact of CBPP has been named as one of the major obstacles hampering CBPP control and eradication (Masiga and Domenech, 1994) livestock keepers were asked to assess losses associated with CBPP. In the study area deaths due to mortality ranged between $1640 in Kajiado and $8 in Nairobi district with average total losses of $1,074,682 annually in only eight districts of Kenya.

Vaccination as a disease control measure

Because of socio-cultural and economic factors, vaccination is the method of choice to reduce the CBPP incidence in a first step before strict sanitary measures can be applied for its eradication (OIE, 1993).Vaccination is practised biannually in the endemic districts of Kenya, and is recommended in recently infected districts where test and slaughter have failed to control the disease. Ring vaccination of in- contact herds is used although this practice has been blamed for the perpetuation of CBPP in areas where it has been practised (Provost, 1994). 59% of the cases reported by farmers were followed by vaccination and 84% of the farmers encountered vaccinations of their animals against CBPP during the last one year mainly by government personnel. In Nairobi, vaccinations only followed the influx of cattle from endemic or newly infected districts while in Tanariver, Mwingi, Makueni, Kajiado, Narok and Thika districts vaccinations were routine and repeated following outbreaks.

Vaccination is free in an attempt of the government to encourage farmers to present their cattle for vaccination. However, some farmers claim having paid for vaccinations which was probably a wrong assumption on their part as CBPP vaccine is usually administered along with other vaccines such as FMD vaccine for which the farmers are expected to pay.

In CBPP endemic districts vaccination coverage ranges between 20% and 60% occasionally reaching beyond 100%, while it rarely goes beyond 25% in the newly infected districts, except in Narok Kitui and Transmara districts. It is encouraging that in the border districts and their neighbours, i.e Marsabit, Mandera, Wajir, Narok and Isiolo, vaccination coverage reached above 75%. Vaccination was, however, irregular and sometimes missed out some endemic districts, even Tanariver which had been consistent in vaccinations. Coverage is on the decline for the last two years probably due to the El-Nino phenomenon which left most roads impassable. To be effective CBPP vaccinations must continue for at least three years (Egwu *et al.*, 1996). The lack of maintaining the required vaccination intensity because of financial constraints and natural influences such as unexpected volumes of rain could be among the reasons for the continued existence of CBPP in Kenya. Variation in vaccination figures between the years was not observed but between the newly infected districts, which practiced only a low key vaccination practice, and the endemic districts.

Vaccination plays a major role in reducing outbreaks as indicated by Nwanta and Umoh (1992) in their study over a 20-year period in Nigeria. This has also been demonstrated specifically in Narok district where vaccination was practised since CBPP reinfection in 1990.Vaccination can be effective only if the cover approaches 100%. Anything less means that there is yeta risk of susceptible cattle contracting the disease (FAO, 1997). Indeed partial vaccination will maintain CBPP (Provost, 1994). This study has demonstrated that an average vaccination coverage of 20-60% in endemic regions in fact maintains outbreaks in this region. However, in Narok, a newly infected district since 1990, the same level of vaccination led to a drastic drop in the number of outbreaks due to more frequent repeated vaccinations as had been suggested by Egwu *et al.* (1996). Partial vaccination has however, failed to clear the district, having still suspected cases of CBPP in 1999. On a national scale, the relationship of vaccine doses used and the number of outbreaks indicated that as the number of outbreaks increased the number of vaccine doses used also increased contrary to what was observed by Nwanta and Umoh (1992) in Nigeria. Apparently, outbreaks in Kenya are followed by rigorous vaccinations which then are repeated as the course of the disease dictates. The strong positive correlation between the vaccine doses used and the vaccine distributed waned especially in the last three years. The explanation given for this drop is that in 1996 drought led to cattle being unavailable for vaccination. Then in 1997 and 1998 the El-Nino phenomenon led to roads being impassable so that vaccination failed in most districts. Furthermore, as there is the need for over 5 million doses of vaccine to cover the cattle eligible for vaccination, vaccination distribution reached only a maximum of 2 million doses which further may explain poor vaccination coverage at least in some districts.

A look at the monthly vaccination practice indicated that most of the vaccinating districts carry out their vaccinations between August and November which is the period when most districts experience the short rains. This is good practice as most cattle are in their resident districts where there is enough water and pastures unless it is a bad year when the rains failed. Thus, any improvements in vaccination practice to reach the desirable 100% (200% if dine biannually) will mean the supply of more vaccine doses to cover the target population. A vaccination coverage of over 100% was observed in districts which attempt to vaccinate biannually.

During the long rains, i.e. February to April, not may vaccinations are carried out due to the inaccessibility of roads or lack of funds as this falls in the second half of the financial year. If the latter is the reason, then any future improvements in vaccination practice would need an improvement in the availability of funds to allow vaccination during this possibly suitable period. Long rains are less likely to fail entirely as short rains. If the inaccessibility of roads is the reason, then improvements in vaccination coverage can only be achieved when during the short rains personnel in the non-vaccinating districts is mobilised to assist in meeting the 100% coverage within this short period. As, like in Nigeria (Nwanta and Umoh, 1992), cattle l begin to move if rains fail, vaccination camps should be established along stock routes to vaccinate cattle on the move as these cattle pose a major risk to unvaccinated cattle with which they may mix during communal grazing. However, in farming communities in Mwingi, Machakos and Makueni vaccination during the wet season may not work well because this is the time for planting. In these districts, cattle are used for ploughing and, hence, the farmers and their cattle are not available during this season. Vaccinations may then be executed during the dry season. This may serve a good purpose as these districts also suffer influxes of cattle from other districts during the dry season.

Factors affecting disease reporting

There are several vernacular names used among the different communities in the study area to describe the disease which, in one way or the other, refers to the affection of the lung. Farmers who are aware of a similar condition in goats, contagious caprine pleuropneumonia (CCPP), are careful to differentiate between the species. Thus, among the Somalis, Ormas and Wardei CBPP is referred to as 'Sambap', 'Somba' and 'Berfur,' respectively, which means 'lung'. The Masai of Kajiado and Narok refer to CBPP as 'Olkipiei' which refers to the affection of the lung; they, however, differentiate between 'Olkipiei' for CBPP in cattle and 'Olkipiei ya mbuzi', a mixture of Masai and Swahili languages for CCPP in goats. The Akamba of Mwingi, Makueni and Nairobi refer to CBPP as 'Mavui' which means lung and differentiating it from CCPP in goats by referring to it as 'Mavui ma ng'ombe' which means 'ox lung'. The Kikuyu of Kiambu, Thika and Nairobi refer to CBPP as 'Murimu wa mahuri' meaning 'lung disease'and 'Murimu wa mahuri ma ngombe' differentiating it from CCPP.

Farmers are aware of the major clinical signs of CBPP which they described well in the questionnaire. Farmers do also carry out a kind of post-mortem examination and the post-mortem findings they reported match well with pathology. In fact, the accuracy of clinical signs and post-mortem lesions described by the farmers indicate that a large proportion of farmers can be trusted to diagnose CBPP correctly. Among the reasons for good knowledge of CBPP of farmers and pastoralists were the presence of the disease, good extension service as well as farmer self education. It is impressive to note that inspite of CBPP having been present for barely 2 years in Thika district the knowledge of CBPP by the farmers was good to very good in 74% of the farmers and fair in only 26%. This was mainly due to farmer self education coupled with vigilant extension service.

Farmers in the study area do not consider CBPP as their number one disease. Other diseases such as trypanosomosis (in Tana River and Mwingi districts), tick borne diseases, anthrax and foot and mouth disease are given top priority. Indeed, the farmers interviewed indicated that CBPP is rather sporadic and losses are rather more long-term than short-term. Reporting is not favoured because of the undesirable implications of slaughter, quarantine and screening. However as there is a general believe among the livestock keepers, and particularly among the Maasai, that vaccination is the only 'cure' for CBPP, they will eventually report the disease; in fact, 80% of the farmers claimed to have reported the disease although often after they have tried other ways of combating it. Hence, farmers and pastoralists will treat, sell, slaughter or practice traditional quarantine before reporting the disease. Farmers will often report CBPP to the CBAHWs or the veterinary office and rarely to the local administration or traditional leaders. In Nairobi disease reporting is said to be greatly hampered by private veterinarians. 60% of the time CBPP is reported using the local name while 30% of the time it is reported only as a respiratory disease and other times as disease following introduction of new cattle or as disease following the movement of cattle from elsewhere. Reasons for not reporting CBPP were the unavailability of veterinary personnel, probably due to structural adjustments among field personnel, the need to contact distant owners, especially among farmers where cattle keeping is only an additional source of income, the lack of confidence in veterinary personnel due to the "high fees they impose on farmers", and long distances to be covered coupled with lack of transportation.

Veterinary personnel in the study area does also admit that CBPP is not a priority disease and most place it in fifth rank after TBDs, FMD, trypanosomosis, endoparasites, anthrax and black quarter depending on the district. Only in Tanariver district CBPP is given first priority by the veterinary personnel and second priority by the farmers which explains why vaccination against CBPP was regular within this district. Generally, while there was agreement between veterinary personnel on ranking of CBPP in the respective districts, the farmers expressed different opinions which may also affect disease reporting.

Other action taken beside vaccination by the veterinary personnel included sampling, quarantine, advise to slaughter and treatment. Treatment is discouraged by the OIE (1995) although there is no doubt that owners of infected animals sometimes treat them (FAO, 1997) which was also confirmed in this study. Even treatment by veterinary staff is in 75% of the cases and especially in recently infected districts due to a misdiagnosis of CBPP as simple respiratory disease or other diseases hence the need for differential diagnosis (FAO, 1997). Often a treatment by the farmer is said to be better than doing nothing. Conventional treatment involves the use of tetracyclines and penicillin-streptomycin combinations. Farmers recorded up to 100% recovery with both drugs. This can only be interpreted as reduction of clinical signs while creating chronic carriers as observed by Mlengeya (1995) in Tanzania. This was substantiated by farmers who claimed that months after treatment and apparent recovery sometimes cattle elicit the same clinical signs. Traditional treatment is practised mainly among the Akamba which in most cases involves the oral administration of herb extracts and tea. Interestingly, the pastoralists of Marsabit administered orally an acacia tree extract and the Somali of Tana River administer lung of infected cattle intramuscularly, similar to the observation of Herbert (1974) among the nomadic Fulanis of Nigeria.

Sampling is only of value if speedy submission of samples to the laboratory can be executed as one of the limitations of CBPP diagnosis is the relatively poor survival of mycoplasmas during transport (Egwu *et al.*, 1996). It is probably because of this understanding that sampling and sample submission is not quite common among veterinary field staff. Quarantine is difficult to impose on communities where cattle keeping is the sole source of livelihood and slaughter of the sick requires full cooperation from cattle owners and/or timely compensation payments needed to restock herds (Egwu *et al.*, 1996). This may explain why these two control measures are unpopular among the veterinary personnel. Slaughter is however, practised to a reasonable extent because it is compulsory in the event of a CBPP outbreak. This study has also demonstrated that the slaughter of positive cases followed by vaccination of in-contact cattle can only perpetuate but not halt the disease. In Thika district CBPP first broke out in 1996 and was followed by illegal vaccinations at first, followed by screening and slaughter of the positives and then legal vaccinations of the in-contact herds.

A quarantine that cannot be withdrawn within one year serves no useful purpose. Based on the incubation period of CBPP of up to 207 days (Provost *et al.*, 1987), infected cases in a herd should be detectable within one year. This study has shown that quarantines sometimes last upto three to ten years which can only lead to farmers losing faith in the quarantine and, thus, moving their cattle illegally as already indicated in veterinary departmental reports. While it is understood that a quarantine cannot be lifted as long as CFT positives are detected, it is upon the veterinary department to ensure that the screening of cattle is effected speedily and timely to allow to withdraw quarantines within the shortest time possible. If screening at two month intervals can result in 3 consecutive negative CFTs then the quarantine can be withdrawn (Egwu *et al.*, 1996).

Abattoir surveillance by experienced meat inspectors, backed up by sensitive serological tests, provides the best chance of diagnosing CBPP (Nicholas *et al.*, 1996). Because the lesions are so characteristic, slaughterhouse monitoring is a powerful tool to be used in detecting introduction and spread of the disease. This study clearly showed that the detection of CBPP outbreaks using abattoir surveillance is not well established in Kenya as records in slaughterhouses are kept of conditions rather than diseases. The fact that no cases were confirmed using AGID alone further indicated that hardly any samples were submitted from the slaughterhouse as the front line for the detection of CBPP outbreaks. Slaughterhouse personnel expressed the general feeling that CBPP cases should be first detected in the field before they arrive at the slaughterhouse. This, of course, is the wrong opinion because the only certain way of detecting CBPP cases is first by the detection of typical lesions and then by laboratory diagnosis. Almost half of the slaughterhouses in the country are under veterinary public health whereas in some districts only the municipalities are under veterinary public health administration. Even more worrying is the fact that 99% of the slaughterhouses in endemic districts and 44% of those in newly infected districts are still under medical public health administration. This scenario stems from the historic fact that all slaughterhouses were originally under medical public health and then gradually taken over by the veterinary public health. Attempts have been made to improve the situation by taking over an additional 6% of the slaughterhouses under veterinary administration. However, since 1997 the Veterinary Department has instructed slaughterhouse personnel to record, report and to send to the laboratory any CBPP suspected lesions and to keep a record of movement permits for possible trace back. Ante-mortem inspection of cattle to detect CBPP and other epizootics has been strenghthened by instructing stock traders (since 1998) to offload cattle only at slaughterhouses mandated to handle cattle from CBPP endemic districts.

Despite fundamental differences in the epidemiology of CBPP and rinderpest, and disparity of available means and tools for combating them, CBPP has long been treated as a mere component of rinderpest control/eradication programmes (FAO, 1997a; Ameh *et al.*, 1995). This fact which can be blamed for the flare up of CBPP in Thika district, as it was not adequately dealt with, since major resources were then directed towards combating rinderpest and CBPP only took second place. Global elimination of rinderpest is so near that it requires only a final thrust; it would now be a major advantage to create an enabling environment for CBPP control in Africa by freeing resources to undertake the required strengthening (FAO, 1998).

6.0 CONCLUSIONS AND RECOMMENDATIONS

It became evident that CBPP no longer occurs only in the endemic regions of Kenya but a new epidemiological zone of newly infected districts in the centre of the country and with the result that CBPP is now present in over 70% of the country. CBPP remains a disease of moving cattle as confirmed by the risk factors identified all relating to movement of cattle.An evaluation of CBPP control strategies practiced in Kenya leads to the following conclusions:

- As screening of cattle before movement is no longer practiced at any meaningful level it should either be abandoned and resources redirected towards other control measures, or revamped to serve the very useful purpose originally meant to.

- Though movement of cattle on hoof has long been discouraged, cattle do still move on hoof from Kajiado district in large consignments through a clean district, Kiambu district. Movement control should be intensified especially between infected and non-infected districts and movement on hoof from Kajiado district should be discouraged.

- However, during times of drought movement control is difficult to effect especially when cattle must move in search of pasture and water. Therefore, vaccination stations and camps are to be established along major stock routes; cooperation of the Veterinary Department with the meteorological department would further add to understand cattle movement during droughts

- Vaccination is an especially effective method of CBPP control if it is practiced with the intensiveness and persistence that is required. It is particularly useful when a slaughter policy is too expensive to be practiced due to the magnitude of the outbreaks seen in Narok district. The practice of slaughter of sick and vaccination of the remaining in-contact cattle only helps to perpetuate CBPP. In an area where the disease appears for the first time it should not be practiced; here CBPP control should rather aim at 'stamping out' positive cases within six months through intensive screening every two months. Further, steps should be taken to strengthen the capacity of the national laboratory in the diagnosis of CBPP particularly with regards to the supply of diagnostics and training of laboratory staff in the use of cELISA. Technical problems of CBPP control should be overcome by supply of sufficient doses of vaccine, release of adequate funds and maintenance of vehicles and equipment both for vaccination and for screening.

- Quarantine imposed on newly infected districts that cannot be withdrawn within at most one year serves no useful purpose and only helps to perpetuate CBPP through illegal cattle movements of farmers due to a quarantine too long.

- CBPP incurs heavy loses but not only in the form of deaths of CBPP infected cattle. A full understanding of the extent and compexity of the total economic loses requires a further comprehensive study to determine these losses in Kenya.A cost-benefit analysis of CBPP control is urgently required in Kenya to come up with the most cost-effective control policy under the predetermined conditions.

- As current laboratory tests are unable to detect all infected animals, particularly those incubating the disease and chronic carriers, the recently developed and validated competitive ELISA should be adopted by the veterinary authorities.

- Abattoir activities in Kenya are not fully geared towards CBPP control as a substantial proportion is still serving under medical public health and the slaughterhouse personnel does not fully comprehend the role of meat inspection in CBPP control as a first line of epidemiological surveillance in detecting new outbreaks. Thus, the Veterinary Department should combine meat inspection with CBPP surveillance by re-educating slaughterhouse personnel in the use of meat inspection for epidemiological surveillance of CBPP. To place these slaughterhouses under the veterinary public health authority would add substantially.

- Farmers do recognise CBPP to some extent and give it some emphasis. While reported outbreaks are recorded and dealt with appropriately, rumours are not recorded though in most instances they are taken seriously and acted upon. Farmers need to be further educated on all aspects of CBPP through seminars, workshops and field days. A major effort needs to bemade to improve the veterinary-farmer interface and to strengthen veterinary services in the medium to long term to ensure adequate reporting of CBPP by the farmer. Recording of CBPP rumours is recommended. The source of infection needs to be adressed more energetically by encouraging CBAHWs, private veterinarians and non-governmental organisations to report the disease and to refrain from treating suspected cases of CBPP. Improvements need to be made in the confirmation of outbreaks in CBPP endemic districts.

Conventional control programmes recently relied more on vaccinations to suppress epidemic events in newly infected populations rather than on reducing the toll of infection in endemic areas and the rate of spread leading to increased numbers of unconfirmed suspect cases in these areas.

- The country is to be rezoned in a CBPP free zone, the recently infected districts, and CBPP endemic districts. Disease surveillance should be intensified in the CBPP free districts with particular emphasis on districts in which CBPP has been reported in the last ten years, i.e. in the districts of Kiambu, Nairobi, Laikipia, Embu, Kirinyaga, Kilifi, Taita Taveta and Mombasa.

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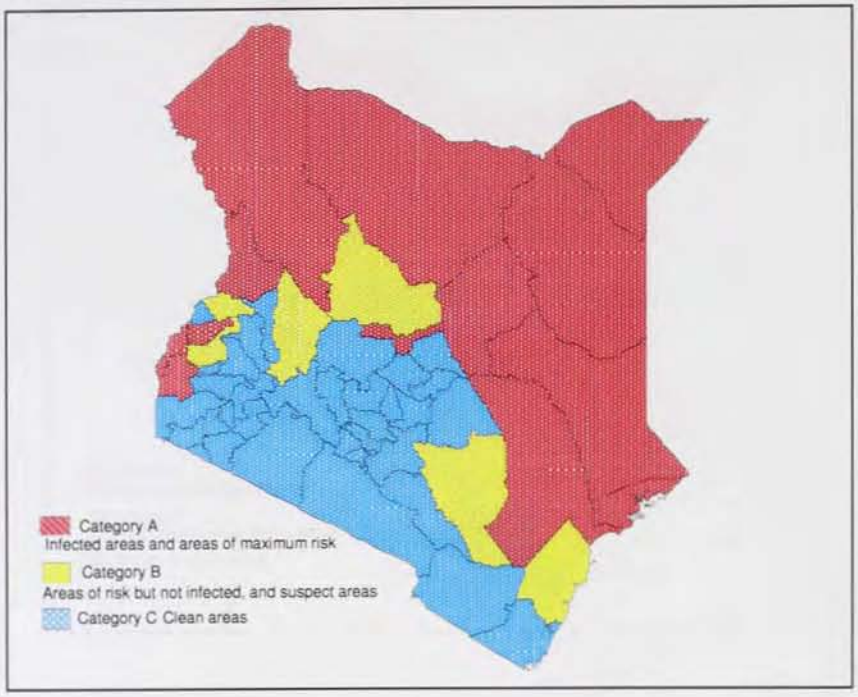
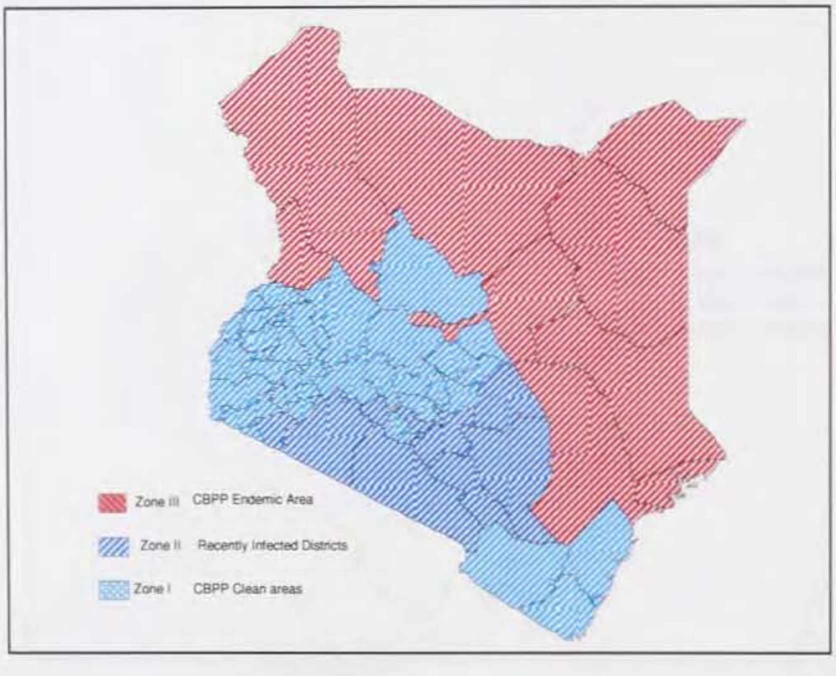
8.0 ANNEXES

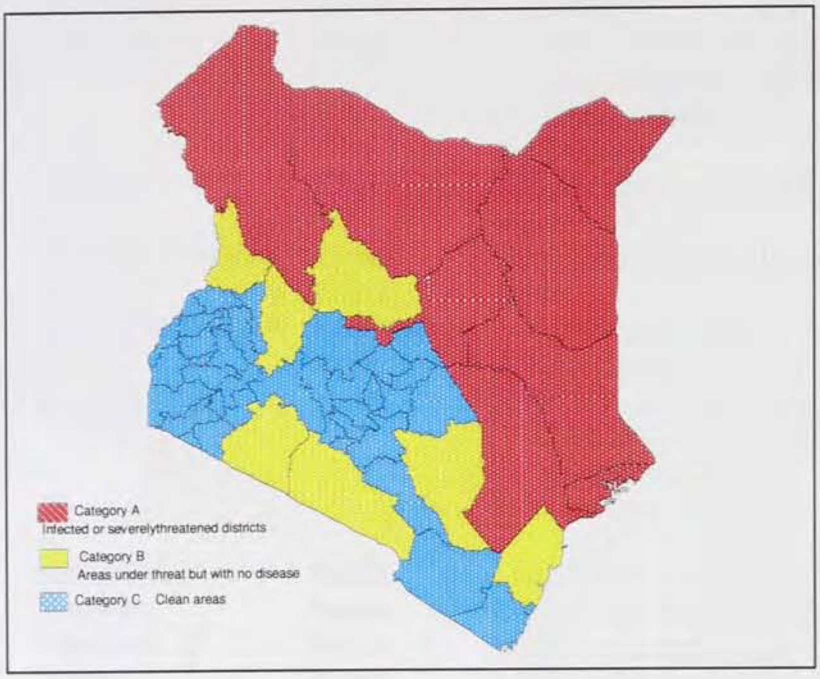
Annex 1a: CBPP zones in Kenya 1982 to 1997



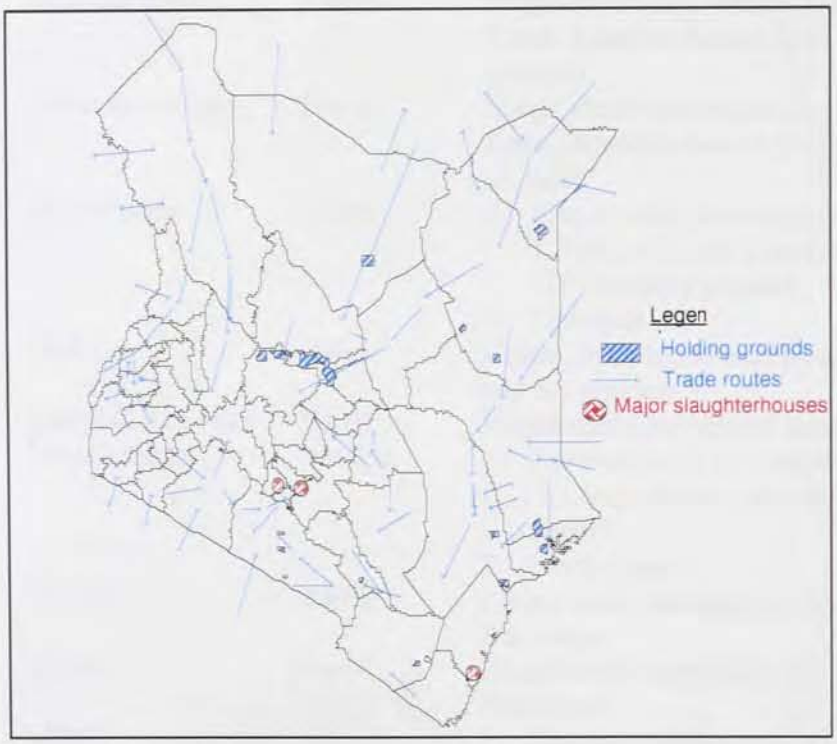
Annex 1b: Suggested CBPP zones in Kenya 1998



Annex 1c: CBPP zones in Kenya, 1975-1982



Annex 2: Approved holding grounds and slaughterhouses in Kenya



Annex 3: Traceback of CBPP outbreaks according to Veterinary department personnel in Kenya

Year	Month	Location	District	Origin
1989	Nov	Ndarakwa	Narok	1. N.E.P cattle purchased by maasai from Dagoretti and Ngong slaughterhouses 2. Tanzania
1989	Jan	Mutomo	Kitui	Illegal cattle movement from Mwakini ranch.
1989	Nov	Embu-Mwea ranch	Embu	Cattle purchased from Ishiara market
1989	Nov	Ishiara	Embu	Isiolo
1989	Dec	Marurumo	Kirinyaga	1. Tanariver district 2. Kitui district
1990	March	Elangata Nterit	Narok	1. N.E.P cattle purchased by maasai from Dagoretti and Ngong slaughterhouses 2. Tanzania
1990	April	Sandyriver	Narok	Local illegal cattle movement
1990	April	Megwara,	Narok	Local illegal cattle movement
1990	April	Marariver	Narok	Local illegal cattle movement
1990	April	Aitong	Narok	Local illegal cattle movement
1990	April	Olkinyei	Narok	Local illegal cattle movement
1990	Feb	Mariakani APRS	Kilifi	1. Maungu ranch 2. Slaughterhouse cattle
1990	March	Elangata Nterit	Narok	Illegal cattle movement from Kibiko in Karai, Kiambu district (S/H holding ground)
1990	March	Olduroto village	Narok	Illegal cattle movement from Kibiko in Karai, Kiambu district (S/H holding ground)
1990	Jan	Olpusimoru	Narok	1. Illegal cattle movement from Kibiko in Karai, Kiambu district (S/H holding ground) 2. Tanzania
1990		Naikara	Narok	Illegal cattle movement by stocktraders and for grazing
1990		Narok G.K. prison	Narok	Illegal cattle movement from Naivasha
1991	Jan	Marula Estate	Nakuru	1. Purchase of N.E.P cattle 2. Grazing maasai cattle from Narok district. 3. Stock-route.
1991	Jan	Oletukat	Narok	Illegal cattle movement from Naroosura
1991	Jan	Suswa	Narok	Illegal cattle movement from Naroosura
1991	Jan	Gilgil	Nakuru	1. Grazing maasai cattle from Narok district

				2. Marula estate
1991	Aug	Lolgorien	Narok	Cattle purchased from Lolgorien market
1991	July	Maungu ranch	Taitataveta	Tanariver district
1991	Nov	ADC complex Kiswani	Kilifi	Kulalu ADC
1991	Feb	Galana ranch	Kilifi	Cattle purchased from Tanariver district
1991	Feb	Galana cattle company	Kilifi	Galana ranch
1991	July	Taita ranch	Taitataveta	Galana cattle company
1991	Jan	Ongata Rongai	Kajiado	Cattle purchased for Dagoretti
1991	Jan	Lasit	Narok	Illegal cattle movement by stocktraders, for grazing and water
1991	Dec	Emarti	Narok	Illegal cattle movement by stocktraders, for grazing and water
1991	Apr	Masandare	Narok	Illegal cattle movement by stocktraders, for grazing and water
1991	Sept	Enkutoto	Narok	Illegal cattle movement by stocktraders, for grazing and water
1991	Jan	Nkareta	Narok	Illegal cattle movement by stocktraders, for grazing and water
1992	Apr	Machakos ranching	Machakos	Mandera
1992	May	TARDA Emali	Kajiado	Emali market
1992	July	Ereri ranch	Laikipia	Isiolo
1992	Aug	Kibarani dairies	Mombasa	Slaughterhouse cattle
1992	Jan	Makueni	Machakos	Cattle purchased from Garissa and Kitui
1992	Jan	Transmara div. And entire district	Narok	Illegal cattle movement for grazing and by stocktraders
1992	Apr	Embakasi	Nairobi	Illegal cattle movement for grazing from Kajiado, Machakos and Kiambu
1993	July	Laikipia airbase	Laikipia	Ereri ranch
1993	Sept	Olkalou	Nyandarua	Grazing Maasai cattle
1994	March	Transmara	Transmara	Cattle purchased from Lolgorien market
1995	Jan	Melelo	Narok	Cattle purchased from Transmara district
1995	May	Gilgil	Nakuru	1. cattle purchased from Samburu district 2. Grazing maasai cattle from Narok district
1996	June	Lokiriama	Turkana	Cattle grazing in Uganda
1997	May	ruiru	Thika	1. Offloading of slaughterhouse bound cattle 2. Grazing maasai cattle from Kajiado
1997	May	South Kadunyi	Bungoma	Pruchase of cattle from N.E.P

Annex 4a: District results of serum samples submitted at the Central Veterinary Laboratory, Kabete, Kenya, 1989 – 1998

District	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Embu	152(22)	15(14)	185(14)	0	5(3)	0	723(21)	0	0	0
Garissa	1988(53)	631(2)	27(0)	35(5)	0	109(2)	1(1)	28(10)	408(16)	2(0)
Isiolo	320(10)	11(2)	13(9)	0	68(30)	11(10)	2(0)	76(4)	0	0
Kajiado	15(0)	0	95(53)	197(23)	31(19)	104(0)	2(0)	5(0)	0	31(7)
Kiambu	22(1)	56(9)	46(9)	94(21)	6(0)	10(0)	0	0	99(20)	19(2)
Kilifi	60(46)	819(32)	197(153)	0	83(2)	0	0	0	73(56)	9(3)
Kitui	265(8)	116(15)	19(0)	1(0)	1(0)	5(0)	7(0)	0	0	0
Machakos	216(20)	15(0)	93(0)	381(8)	5(0)	31(14)	0	113(24)	16(8)	2(0)
Mombasa	40(40)	0	84(8)	76(61)	0	0	0	0	0	0
Muranga	6(0)	0	0	0	0	0	70(0)	0	0	0
Mwingi	137(0)	76(2)	0	0	0	0	154(0)	0	0	0
Nairobi	14(0)	95(13)	156(23)	375(41)	3(3)	77(4)	307(1)	59(3)	40(18)	9(0)
Nakuru	261(0)	189(0)	137(5)	155(48)	35(6)	4(0)	6(3)	93(7)	18(0)	13(4)
Narok	5(0)	50(13)	48(6)	0	4(1)	5(4)	0	0	0	0
Turkana	26(1)	0	0	6(1)	2(1)	0	0	0	0	0
Uasingishu	11(0)	0	0	0	0	0	0	0	49(4)	0
Kericho	0	69(11)	0	309(38)	0	0	0	0	0	0
Makueni	0	6(0)	17(0)	0	0	2(2)	0	0	0	0
Wajir	0	14(0)	0	0	0	0	0	0	0	0
Taitataveta	0	0	49(36)	0	0	0	0	0	0	0
Thika	0	0	34(0)	0	1(0)	0	0	0	85(18)	0
Laikipia	0	0	0	267(8)	6(3)	0	71(0)	0	0	0
Lamu	0	0	0	0	35(0)	0	5(0)	0	0	0
Nyandarua	0	0	0	0	285(42)	0	0	0	0	0
Nyeri	0	0	0	0	16(2)	0	0	0	0	0
Transmara	0	0	0	0	38(16)	0	2(2)	6(6)	0	0
Bungoma	0	0	0	0	0	11(0)	0	0	0	0
Meru	0	0	0	0	0	1(0)	0	0	0	0
Samburu	0	0	0	0	0	4(4)	0	0	0	0
Tanariver	0	0	0	0	0	80(0)	0	0	0	0
Homabay	0	0	0	0	0	0	0	0	2(1)	0
Kuria	0	0	0	0	0	0	0	0	6(1)	0

( ) =CBPP positive tested sera

Annex 4b: District results of lung samples submitted at the Central Veterinary Laboratory, Kabete, Kenya, 1989 – 1995.

District	1989	1990	1991	1992	1993	1994	1995
Embu	1(1)	26(21)	5(0)	0	10(7)	0	0
Isiolo	2(2)	5(2)	16(8)	0	2(0)	2(0)	1(1)
Kiambu	3(3)	11(9)	78(39)	6(0)	0	0	0
Kilifi	2(2)	3(1)	14(8)	16(2)	0	0	0
Machakos	8(7)	6(2)	4(0)	0	0	1(1)	0
Nairobi	3(1)	7(5)	1(0)	2(0)	2(1)	0	0
Kajiado	0	3(3)	1(1)	15(0)	0	1(0)	1(0)
Kitui	0	5(1)	1(0)	0	0	1(0)	0
Nakuru	0	1(1)	5(2)	1(0)	2(2)	1(1)	5(2)
Narok	0	8(6)	3(0)	1(1)	0	1(0)	0
Makueni	0	0	2(0)	0	0	0	0
Mombasa	0	0	1(1)	2(1)	0	0	0
Kericho	0	0	0	2(0)	0	0	0
Thika	0	0	0	1(0)	0	0	0
Laikipia	0	0	0	0	10(9)	0	0
Bungoma	0	0	0	0	0	1(0)	0
Garissa	0	0	0	0	0	1(1)	2(0)
H/bay	0	0	0	0	0	1(0)	0
Nyandarua	0	0	0	0	0	5(4)	0
Total	19(16)	75(51)	131(59)	57(13)	26(7)	9(3)	332(168)

( ) = CBPP positive samples

Annex 7: Geographical data of study area, Kenya, 1999

District	Tribe	Area (km^2)	Temperature zone	Moisture Zone	Average Annual rain (mm)	Vegetation	Economic activity	Cattle population	Potenti pla grow
Tanariver	Orma Pokomo Somali	31276	1 hot to very hot	VI-VII arid to very arid	150-550	bushland, scrubland and desert scrubland	cattle keeping – Orma and Somali Crop farming - Pokomo	378,329	low to low
Mwingi	Akamba	7452	1 hot to very hot	VI-VII arid to very arid	150-550	bushland, scrubland and desert scrubland	cattle keeping and crop farming	168300	low to low
Makueni	Akamba	6691	1and 2 warm to very hot	V-VI semiarid to arid	800 - 900	bushland and scrubland	cattle keeping and crop farming	215000	mediu low
Kajiado	Maasai	17944	1,2,3 and 4 warm temperate to very hot	V- VII semiarid to	150 - 900	bushland, scrubland and desert scrubland	cattle keeping and crop farming	633338	mediu very l

Narok	Maasai	12241	1,4,5,6,7 cool temperate to very hot	II - VII subhumid to very arid	150 - 1000	moist and dry forest to desert scrubland	cattle keeping and crop farming	760153	very l extre hi
Nairobi	Mixed	599	4,5,6,7 warm temperate to very arid	II -V semihumid to semiarid	450 - 1400	dry forest and moist woodland to bushland	cattle keeping and crop farming	15000	high t
Thika	Kikuyu	1222	4,5,6 warm temperate to fairly cool	I -IV humid to semiarid	600 - 2700	moist forest to bushland	cattle keeping and crop farming	107041	medi very
Kiambu	Kikuyu	1087	3,4,5,6 fairly warm to fairly cool	I -IV humid to semiarid	600 - 2700	moist forest to bushland	cattle keeping and crop farming	123900	medi very

Annex 8a: Farmer questionnaire

Questionnaire number: --Da te---------------
District:---
Map reference:--
Place name:---
Name of the farmer/spouse/herdsman (i.e the person interviewed):-------------------------------
Address:---

A. Household data

1. How many family members are there?
----
2. Who is the head of the family?
----
3. What is the level of education of the family head?
----
4. Is cattle keeping the major source of income?
   Yes
   No
5. If not(so) what is the major(additional) source of income?

B. Herd size, production system and management

1. Herd:
   Breed(s):----------------------
   Size:--------------------------
   2. Production:
      Dairy:
      Beef
      Dual
      Other, specify

3. Movement:
   Settled
   Nomadic to where?
   When?----------------------
   Trader to where?

   When? -------------------

4. Grazing:
   Common where? ------------------------ When?------------------------------ Enclosed
   Zero
   Mixed

5. Production system:
Traditional pastoralist
Mixed farm
Cooperative ranch
Commercial ranch
Zerograzing

C. Animal health data

1. What are the important diseases among your cattle and how do you rank them? (starting with the most important)
   1
   2
   3
   4
   5
2. Do you have problems of "pneumonia - like" diseases in your herd?
   Yes
   No
3. What are the major clinical signs of the respiratory disease you have problems with in your herd?

   Do you know CBPP?
   Yes
   No
5. If yes, what are the symptoms
   ----
6. What is its local name ?
   ----
7. Has it ever affected your cattle?
   Yes
   No

8. When was the last time you experienced the disease among your cattle?
   1
   2
   3
   4
   5 years ago
9. What were the age groups affected ?
   Adults (indicate age) --
   Calves (indicate age) ------------------------------------
10. What were the symptoms ?
   Adults---
   Calves--
11. Did you experience deaths in CBPP cases (how many)?
   Yes --
   No
12. About how much money in total did you loose due to such deaths?
   Ksh---
13. What would you attribute to the cause of the disease?
   Purchased animals
   Communal grazing
   Wildlife
   Movement of animals
   Proximity to trade routes
   Other, specify
14. Has there ever been any rumors of CBPP in this area?
   Yes
   No
15. When was the last time there was such a rumor?
   ----
16. Where did it come from?
   ----
17. Did you report the rumors?
   Yes to -----------------------------
   No
18. What action was taken?

D. Disease reporting and veterinary intervention

1. What do you do in case of CBPP?
   Nothing
   Treat
   Other, specify
2. Do you report such cases?
   Yes
   No
3. To whom?
   person chosen by community
   CBAHW
   Veterinary office
   Other, specify
4. If yes what action is usually taken?
   Slaughter
   Vaccination
   Quarantine
   Treatment
   Other, specify
5. If not, why not?
   Need to contact distant owner
   Fear of reporting the disease
   Lack of confidence in the veterinary service
   Poor infrastructure
   Long distance
   Bad weather
   Others, specify
6. How much money do you loose to quarantine?
   ----
7. How much money do you loose due to slaughter of CBPP animals (compared to the slaughter of a healthy animal)?

E. Vaccination and treatment

1. In case of treatment what is the drug that is used?

----

2. Out of 10 animals, how many recover?

----

3. Do you administer traditional treatment to your animals?
   Yes
   No
4. If yes, what is the name of the treatment and mode of application?

----

5. Out of 10 animals, how many recover?

----

6. What is the cost of treatment per animal?
   Conventional treatment---
   Traditional treatment--
7. Do you have your animals vaccinated against CBPP?
   Yes
   No
8. Who vaccinates them?
   CBAHW
   Myself
   Veterinary personnel
   Other, specify
9. When were your cattle last vaccinated against CBPP?

----

10. Which age groups were vaccinated?

----

11. What was the reason for the vaccinations?
    Routine (disease endemic)
    Outbreak
    Rumors of disease
    Other, specify
12. Do you pay for vaccinations?
    Yes
    No
13. How much per animal?

F. Cattle movement patterns

1. How are cattle movements in this area? (Please indicate on the map)

----

2. Is there cattle rustling in this area?
   Yes
   No
3. Who are the rustlers?

----

4. Do you yourself move animals?
   Yes
   No
5. If yes to where and why?

G. Any other comments or suggestions?

Annex 8b: Veterinarian questionnaire

Questionnaire number--Date----------------------
District:--
Map reference:---
Place name:---
Name of Officer:---
Address:---

1. What are the farming systems in this area?(Please estimate the proportions in %)
    - Traditional pastoralist herds
    - Mixed farms
    - Cooperative and/or commercial ranches
    - Zerograzing
2. Is CBPP a common problem in this area?
    - Yes
    - No
3. How would you rank the disease among the other important diseases? (the most important at the top)
    1
    2
    3
    4
    5
4. Do you think the disease is ?
    - Endemic
    - Emerging (new)
    - Re-emerging
5. Is the disease on the
    - Increase? Explain ---
    - decrease Explain ---
6. Do the farmers usually report the disease directly to you?
    - Yes
    - No
7. If not how then?
    - Through CBAHWs
    - Through local leaders
    - Other, specify
8. How do they report the disease to you?
    - Respiratory disease
    - Disease following introduction of new animals
    - Disease following movement of animals from other regions
    - Different syndrome in adults and in calves
    - Unknown disease
    - Other, specify
9. Who else works with you towards disease control?
    - CBAHWs
    - Private veterinarians
    - Non governmental organisation(s). Please mention them ----------------------------------
10. Do they report the disease to you?
    - Yes
    - No
11. If not, why not?
    ----
12. What would you attribute to the presence of the disease?
    - Purchased animals
    - Communal grazing
    - Wildlife
    - Movement of animals
    - Proximity to trade routes
    - Other, specify
    ----
13. How are cattle movements in this area? (Please indicate on the map)
14. When was the last time you experienced the disease in this area? (Indicate month and/or season)
    1
    2
    3

4
5
years ago

15. Was it a major outbreak?
    Yes
    No
16. About how many animals were involved?
    ----
17. How many died?
    ----
18. What action did you take?
    Notification to the chief veterinary field officer
    Quarantine
    Vaccination
    Post-mortem on death
    Sampling for laboratory diagnosis
    Slaughter of the sick in your district.
    Other, specify.
19. Do you vaccinate against CBPP?
    Yes
    No
20. How often and which age groups?
    Yearly adults calves
    Other, specify.
21. What are the reasons for vaccinations?
    Routine(endemic area)
    Outbreak
    Rumors
    Other, specify
22 Are there any rumors of the disease in this area?
    Yes
    No
23. How are the rumors and who brings them up?
    ----
24. Do you take any actions towards such rumors?
    Yes
    No
25. If yes, what actions?
    Investigation
    Verification
    Other, specify
26. If not, why not?
    ----
27. Do you get any reports of the disease from slaughterhouses?
    Yes
    No
28. What do you do about them?
    ----
29. What problems do you encounter in control of CBPP?
    Lack of adequate personnel
    Lack of adequate funds
    Lack of transport
    Lack of adequate vaccine
    Lack of adequate communication
    Other, specify
30. What in your opinion can be done to assist you in control of this disease?

Annex 8c: Slaughterhouse questionnaire

District---
Map reference---
Name of slaughterhouse---------------------------------------
Name of veterinarian ---
Address---

1. What is the number of cattle slaughtered daily in this slaughterhouse?

----

2. Where do the animals come from?

----

3. Do animals arrive on
   hoof ? (--------%)
   by road? (---------%)
4. Do animals always have a movement permit?
   Yes
   No
5. What do you do with animals without a movement permit?

   ----

6. Do animals arrive directly to the slaughterhouse?
   Yes
   No
7. If not
   a) from which slaughterhouses do they arrive?
   b) why? ---
8. Do you sometimes experience an unusual increase in the number of animals for slaughter?
   Yes, explain
   No
9. What are the reasons for such an increase?
   Other slaughterhouses not functioning
   Compulsory slaughter
   Drought
   Disease, specify
   Other, specify
10. During which months of the year do you observe such increases?

    ----

11. Do you have a holding ground?
    Yes
    No
12. If not where then do you hold your animals before slaughter?

    ----

13. Are all the animals in the holding ground slaughtered within this slaughterhouse?
    Yes
    No
14. If not where are they slaughtered?

    ----

15. How long do the animals remain in the holding ground?

    ----

16. Do the animals graze in the neighbourhood before slaughter?
    Yes
    No
17. Do they mix with local animals?
    Yes
    No
18. Do you do ante-morten inspection of animals?
    Yes
    No
19. If yes, who does it?
20. If not, why not?

    ----

21. Do you encounter cases of CBPP during
    a) ante-mortem
       Yes
       No
    b) slaughter
       Yes

No

22. How would you rank it among the diseases you encounter at
    a) ante-mortem (starting with the most important)
        1
        2
        3
        4
        5
    b) slaughter (starting with the most important).
        1
        2
        3
        4
        5
23. When was the last time you encountered CBPP (indicate also months)?
        1
        2
        3
        4
        5 years ago.
24. What action do you normally take in such cases?
        Notify the CVFO
        Notify veterinarian of place of origin of the animals
        Notify area veterinarian
        Take samples for confirmation of disease _ at ante-mortem
        _ at slaughter
        Other, specify
        ----
25. Do you hold a specific mandate to slaughter CBPP animals?
        Yes
        No
26. When was the last time you slaughtered such animals?
        1
        2
        3
        4
        5
        years ago
27. Where were they from?
----
28. How is the movement of animals in this area?
----
29. Do you ever heard of rumors of the disease in this area?
        Yes
        No
30. When was the last time you experieced such a rumour?
    ----
31. What action did do you take?
    ----
32. Do you think slaughterhouses have a role to play in the control of CBPP? control?
        Yes
        No
33. How do you think the control of CBPP through slaughterhouses can be improved?
    ----
34. Any other suggestions concerning the disease?

Annex 8d: CBAHW questionnaire

Questionnaire No.-- Date------------------------------

District: --

Map reference: ---

Place name: --

Name of the-in charge: ------------------------------------

Address: ---

1. What is your role in this community?

----

2. Whom do you work with (government or non-governmental body) ?

----

3. What kind of training have you received in the field of animal health care?

----

4. What are the most important diseases in this area? (Please rank them starting with the most important)

   1
   2
   3
   4
   5

5. Do you know CBPP?

   Yes
   No

6. What are the symptoms?

7. What is the local name of the disease?

8. What do you think is the cause of the disease?

----

9. Are the farmers aware of the disease?

   Yes, why?

   No, why?

   ----

10. Do the farmers report the disease?

   Yes
   No

11. If not why not. Rank the reasons in order of importance?

   1
   2
   3
   4
   5

12. What are the channels of disease reporting for you as a CBAHW?

----

13. Do the farmers report the disease to and/or through you?

Yes

No

14. What problems do you and the farmers face in disease reporting?

Need to contact distant owner

Fear of reporting the disease

Lack of confidence in the veterinary service

Poor infrastructure

Long distance

Bad weather

Others, please specify

15. Do you experience outbreaks of CBPP in this area?

Yes

No

16. When was the last time you experienced such an outbreak? (Please indicate the month)

1

2

3

4

5

years ago.

17. Do you experience rumors of the disease in this area?

Yes

No

18. What is usually the origin of such rumors?

----

19. What do you do about such rumors?

----

19. Are there regular vaccinations for CBPP?

Yes

No

20. What is the reason for such vaccinations?

Routine (endemic area)

Outbreak

Rumor

Ring vaccination

21. Do you yourself vaccinate?

Yes

No

22. Which age groups do you vaccinate?

----

23. How much do you charge for such vaccinations?

----

24. Do you treat animals which have CBPP?

    Yes

    No

25. What drugs do you use?

Traditional---Con ventional-----------

----

26. Out of 10 animals, how many recover?

    Traditional treatment--

    Conventional treatment---

27. Can you describe to me the cattle movements in this area?(Please indicate on the map)

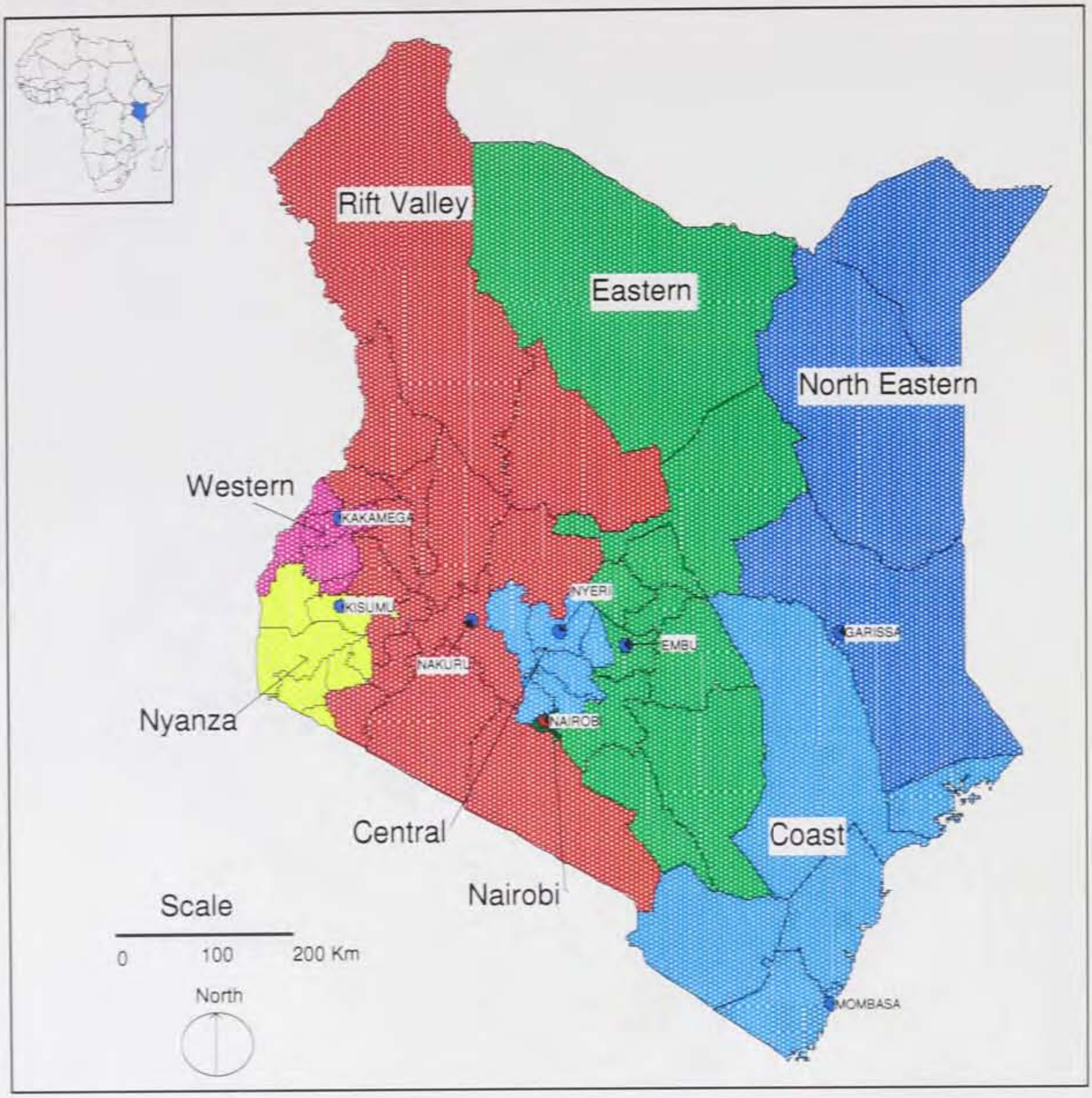
----

28. What in your opinion can be done to improve on disease reporting and control?

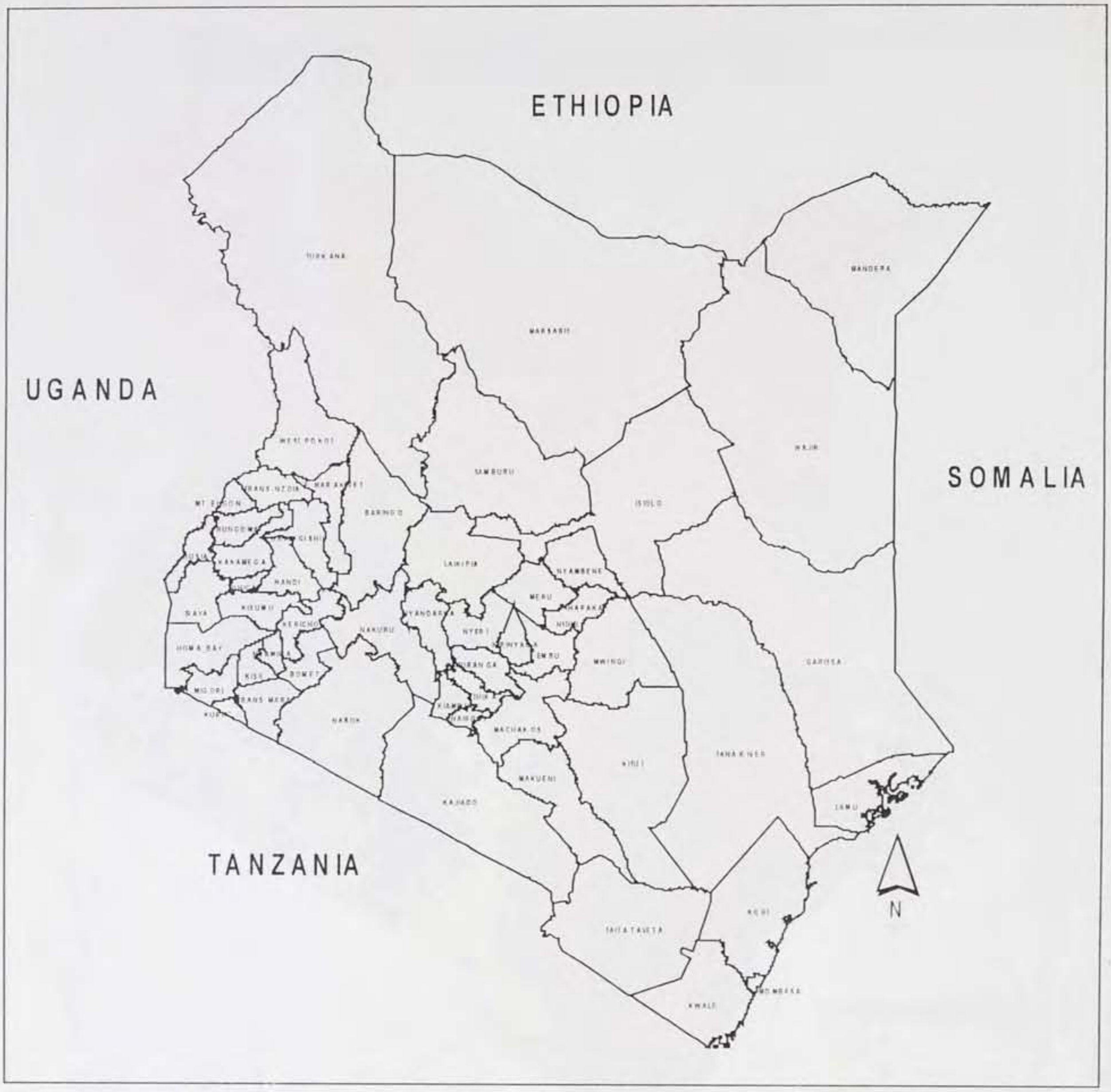
----

29. What other suggestions do you have concerning CBPP disease and control?

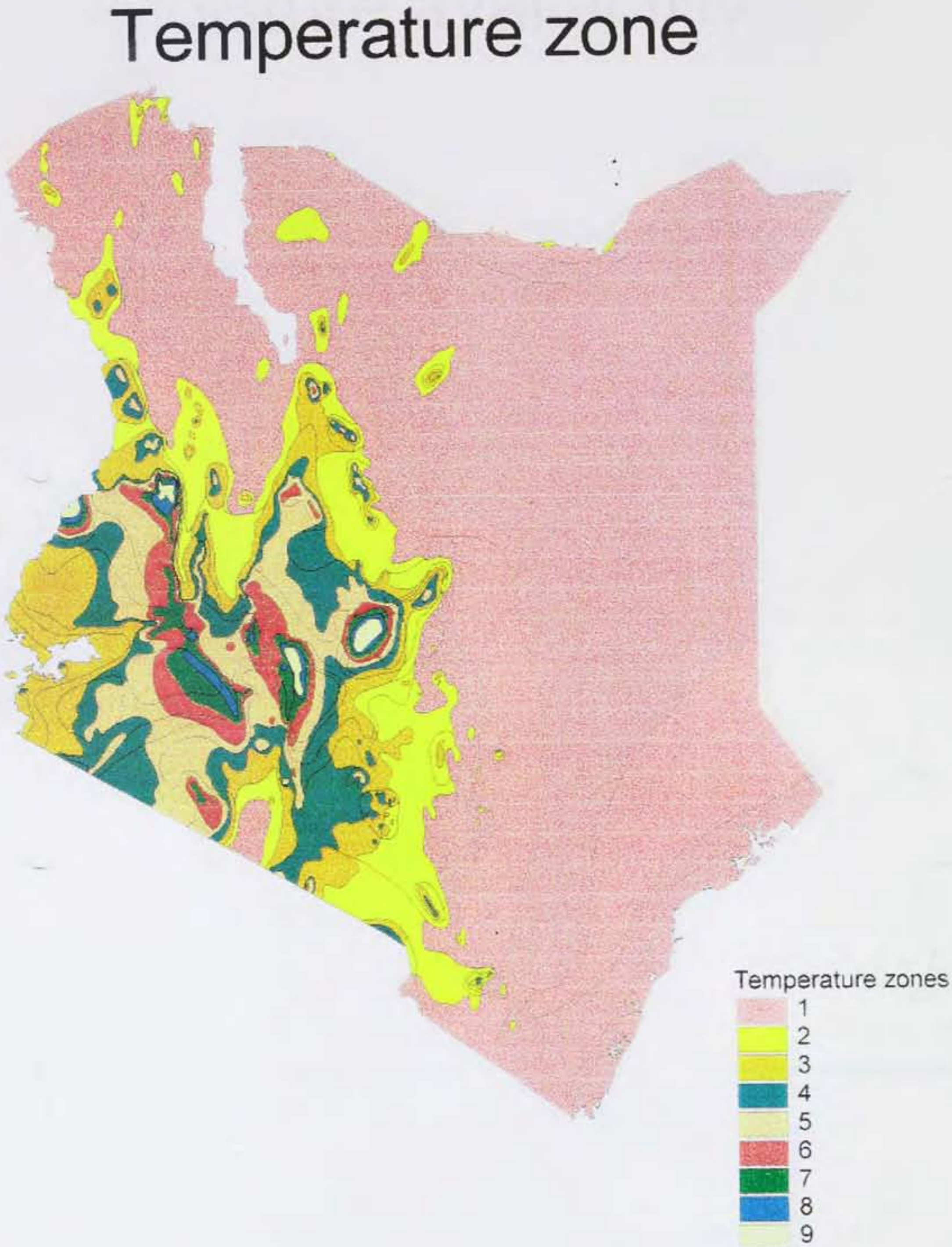
Annex 9a: Administrative map of Kenya: Provinces and Provincial Towns



Annex 9b: Administrative districts of Kenya

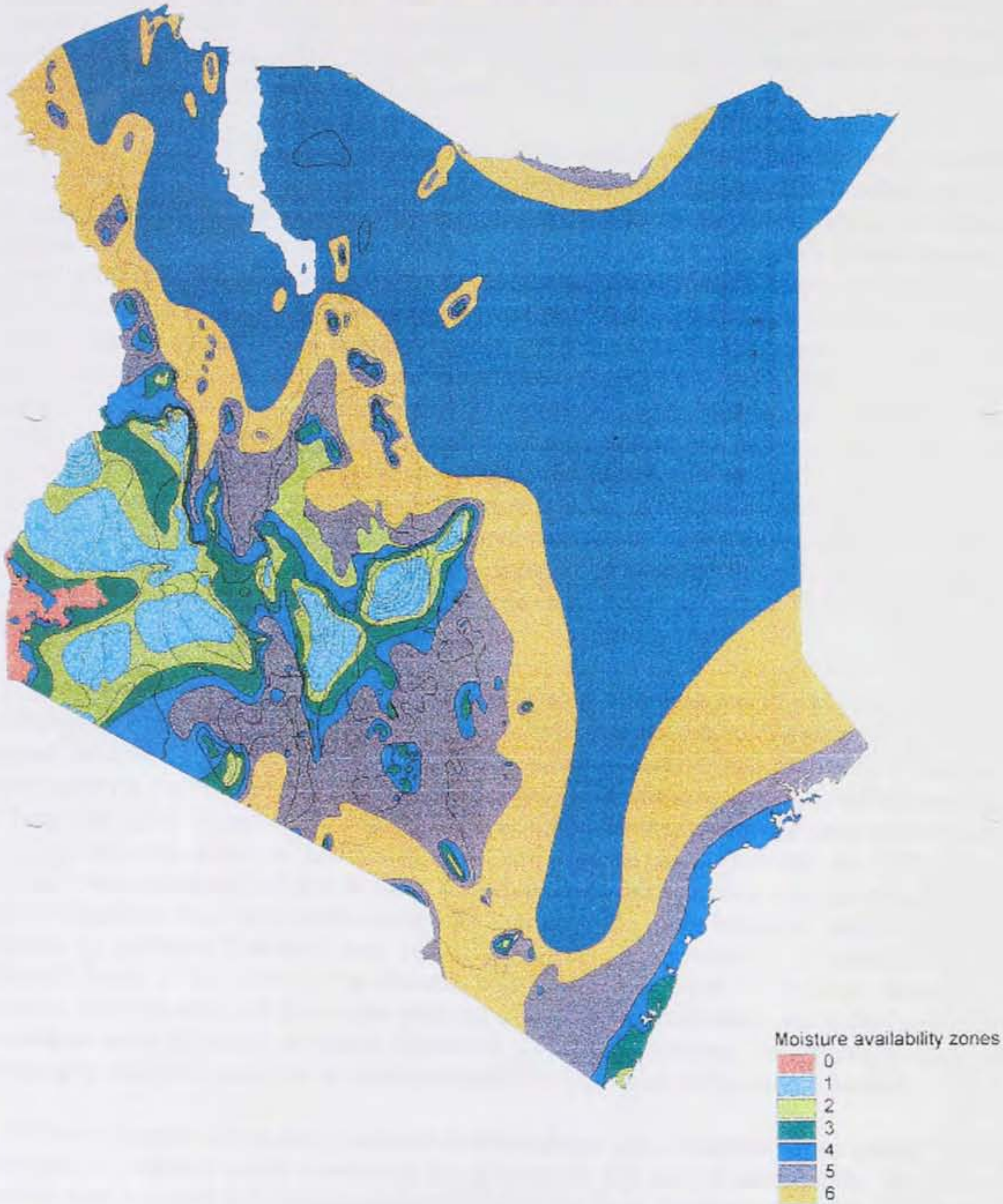


Annex 9c: Temperature zones of Kenya



Annex 9d: Moisture availability zones of Kenya

Moisture availability



Annex 10: CBPP in Kenya, 1900 – 1970 (Kariuki, 1971).

Vast land was acquired by a few European settlers around Nairobi between 1900 and 1905. A pedigree exotic cattle that arrived in the Kenyan highlands in 1901 was reported to have died of pleuropneumonia (Huxley, 1953) and in 1904 native oxen bought from Kavirondo by Lord Delamere came with "virus of pleuropneumonia". The annual report of the Ministry of Agriculture of 1905 and 1906) indicated that pleuropneumonia necessiated the slaughter of all native stock to protect the exotic cattle around Nairobi.

In 1907, thirteen outbreaks were reported all within twenty miles of Nairobi except outbreaks in Baringo, Ravine and Embu. In 1908, another outbreak was reported in Ukambani and Laikipia. According to the reports of the Ministry of Agriculture of 1911 and 1912, the disease was confined to a few herds in Laikipia during this period. These few herds joined the rest of the Maasai cattle, which had been moved from the northern side of the Uganda railway, in December 1912. No doubt this move introduced the disease into highly susceptible cattle to the south of the railway where it caused many deaths between 1912 and 1914. Movement of a large number of oxen by the army during the first world war (1914 – 1918) was responsible for outbreaks around Ngong in 1917 and around Kajiado and Kiu area in 1918. Movement of Maasai cattle was associated with an outbreak at Njoro in 1919. At the same time a new outbreak which spread to Eastern Uganda was associated with movement of cattle by the army. Infected oxen bought at Gilgil were responsible for a new outbreak at Rumuruti. In 1920 illicit movement of cattle was again associated with thirty six outbreaks which occurred in Nyeri, Nandi, Naivasha, Uasin Gishu and Lumbwa. An outbreak in Nyanza at the same time was due to cattle being smuggled from Uganda and Maasailand. Thus in 1920, the disease was widespread in Maasailand, Kiambu, Eldoret, Suk, Nandi, Nyanza and Laikipia.

A new outbreak which had started in South Ethiopia was reported in 1921 at Moyale. Due to movement of stock, the disease spread to Meru, Samburu and Isiolo. Twenty-six outbreaks were reported in Nakuru, Uasin Gishu, Transnzoia, Lumbwa and Nyeri between 1922 and 1924. Severe outbreaks attributed to cattle bought at sales yards occurred at Gilgil, Subukia and Solai in 1927 amounting to 28 outbreaks during that year. In 1929, new outbreaks were confined to farms enclosing infected areas of Maasailand and the Central Rift Districts. In 1930, three new outbreaks were reported and one of them occurred when the Suk tribe was granted permission to graze in Samburu and their cattle came into contact with other infected animals. In 1931, an outbreak in northern Nanyuki was associated with the movement of infected cattle from Samburu. From 1932 – 1935 the disease was mainly confined to Nyanza, Maasailand and Samburu. In 1936 although few cases were reported from settled areas and Kajiado district; local quarantines were imposed in Narok district at Loitoktok, Kedong Valley and Uaso Nyiro. In 1938, a new outbreak occurred in cattle belonging to Ethiopian refugees at Marsabit.

By 1939 the disease was mainly confined to Maasailand and Samburu. In the period 1940-1949, movement of infected cattle introduced the disease in the settled areas again. In 1941, a new outbreak was reported in Laikipia originating possibly from Samburu. In 1942 outbreaks which were traced back to movement of work oxen from Laikipia were reported at Nyeri and Thika. In 1943 illegal movement of cattle from Maasailand was responsible for an outbreak in Ndeiya location of Kiambu district. A new focus of disease began in Meru by movement of cattle from Samburu in 1945. Cattle belonging to Somalis living in Nairobi municipal area of Eastleigh and National Park were also discovered infected in the same year. These cattle infected others in Nairobi Veterinary District in 1947. Squatters trying to move their cattle from danger thus introduced the disease into Machakos District while work oxen moved from Nairobi area introduced the disease in Kiambu and Maragua areas.

In 1948 movement of infected cattle from Nairobi introduced the disease to the Naivasha/Gilgil area, which had been free from the disease for twenty years. Infected purchased cattle at Naivasha intoduced the disease to Mombasa Island and Songhor area during the same year. This outbreak was controlled when farmers agreed to slaughter the infected cattle in 1949. Following the vaccination of cattle with an avianised vaccine in Samburu District, no new outbreak was recorded in Samburu in 1954 for the first time in twenty years. Better communication, organisation and slaughter of suspect and infected cattle at Archers Post abattoir is thought to have helped to eradicate the disease from Samburu during this period. This is not the case in Maasailand where outbreaks continued to occur in Kajiado and Narok district. Six outbreaks were reported in Narok between 1952 and 1956. A severe outbreak occurred in 1958 in the Trans-Mara area of Narok inspite of a massive vaccination programme in 1957. In 1959, twelve outbreaks were reported and the number of cattle in quarantine was 23,000. The drought of 1960-1961 followed by floods helped to disseminate the disease in many parts of Maasailand. Twenty and thirty foci were reported in Kajiado and Narok districts respectively. During the same period the disease was reported in the Turkana district at the border of Sudan. Illegal movement of cattle was responsible for the spread of the disease from Maasailand and to Ndeiya location of Kiambu district in 1962. In 1963 the disease was confirmed in a group of cattle stolen from Uganda in an area Northwest of Lodwar in Turkana District. In 1966 an outbreak of the disease occurred in cattle that had been purchased by the Livestock Marketing Division (LMD) of the Ministry of Agriculture at Wajir and Mandera and held at Isiolo.The outbreak spread to Samburu District in 1967 as a result of illegal cattle movement.

In 1968 the LMD bought cattle at Mudogashe in Garissa district and these animals were found to be infected with pleuropneumonia. These animals belonged to Somalis who had gone to Somalia during the Kenya/Somalia trouble. During the 1969-70 period the disease was confirmed in cattle purchased from theNorth Eastern province of Kenya and held in various holding grounds. It threatened to spread to Samburu district and spread into Lamu district and at one time into Machakos District. Maasailand and Turkana Districts remained enzootic areas although no new outbreaks were reported.

Annex 11: Quarantine imposition in Kenya following CBPP outbreaks in Kenya, 1989-1998

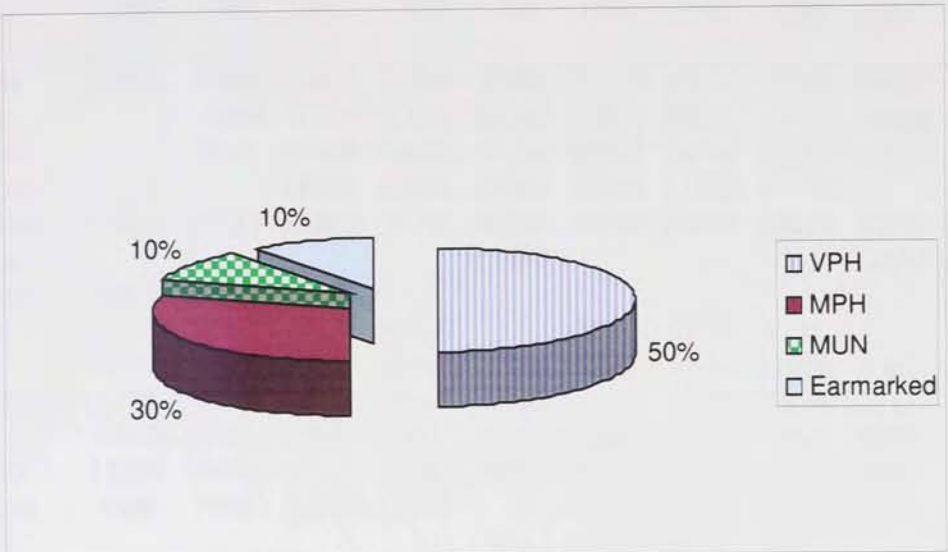
District	Location of outbreak	Quarantine Imposition date	Quarantine withdrawal date	Number of days in quarantine
Embu	Embu mwea ranch karaba loc.	Nov-89	Apr-93	880
Embu	Ishiara market evurore loc.	Nov-89	Apr-91	180
Embu	Kiambere loc. Gachoka div	Jul-93	Mar-95	605
Embu	Muninji loc. Siakago div	Jul-93		
Garissa	Sankuri	Jan-90		
Kajiado	Ngong	Feb-93		
Kajiado	Mashuru(central kaptiei)	Dec-93		
Kajiado	Kitengela	Apr-94		
Kiambu	Karai	Aug-88	Oct-97	3345
Kiambu	Ndeiya	Aug-88	Oct-97	3345
Kilifi	Mariakani APRS	Apr-90	Aug-93	850
Laikipia	Ereri ranch(nanyuki)	Jul-92	Sep-95	790
Laikipia	Laikipia airbase(nanyuki)	Jul-93	Sep-95	425
Laikipia	Withare(sirima loc. Lamuria div	Jun-94	Sep-95	450
Machakos	N.Y.S yatta	Dec-88		
Machakos	Athiriver	Sep-94		
Machakos	Matungulu	Oct-94		
Machakos	Komarock	Jul-94		
Machakos	Kathekani ranch	Sep-96		
Machakos	Lukenya	Jul-97		
Makueni	Mavindini	Feb-92	Oct-95	970
Meru	Lewa downs	Jul-89	Nov-89	120
Mombasa	Kibarani dairies(changamwe division.)	Mar-92	1995	
Nakuru	Marula estate (Naivasha)	Jan-91		
Nakuru	Gilgil division.	Jan-91		
Nakuru	Kedong ranch	1992	1996	1460
Narok	Narok G.K prison	Apr-90		
Narok	Loita loc.(olduroto village)	Mar-90		
Narok	Naikara loc.	Apr-90		
Narok	Oletukat(illdamat loc. East mau div.)	Jan-91	1993	1095
Narok	Lolgorien div.	Sep-91		
Narok	Emarti	Dec-91		
Narok	Masandare(Ewaso nyiro osupuko div.)	Apr-91		
Narok	Transmara div and entire district	Mar-94		
Narok	Olderkesi(naroosura loc.)	Mar-90		
Narok	Enkoireroi(naroosura loc.)	Mar-90		
Narok	East mau	Jan-91		
Taita taveta	Taita ranch(voi division)	May-91		
Thika	Ruiru	Jul-97		
Thika	Thika	Jul-97		

Annex 12a: Classification of slaughterhouses per district, Kenya.

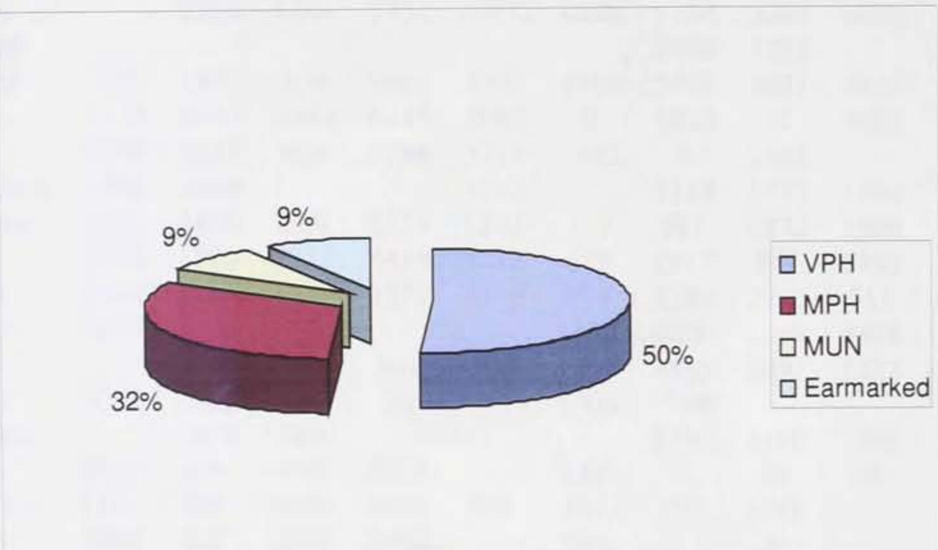
Category 1	Category 2	Category 3	Category 4
Nyandarua	Kericho	Kisii	Tana river
Muranga	Kisii	Laikipia	Isiolo
Kiambu	Laikipia	Kitui	Meru north
Kirinyaga	Kitui	Koibatek	Meru south
Kwale			Moyale
Kilifi			Mwingi
Taita taveta			Garissa
Bungoma			Wajir
Kakamega			Mandera
Busia			Bondo
Trans nzoia			Kuria
Kisumu			Gucha
Kajiado			Nyamira
Uasin gishu			Nyando
Nakuru			Rachuonyo
Nyeri			Suba
Thika			Baringo
Lamu			Bomet
Malindi			Keiyo
Mombasa			Marakwet
Embu			Nandi
Machakos			Narok
Makueni			Samburu
Mbeere			Trans mara
Siaya			Turkana
Lugari			West pokot
Butere			
Mt. Elgon			
Teso			
Vihiga			
Nairobi			
Nyandarua			

Category 1 under VPH
Category 2 VPH only in municipalities
Category 3 Earmarked for take over by VPH
Category 4 under MPH

Annex 12b: Administration of slaughterhouses in newly infected districts at present in Kenya



Annex 12c: Administration of slaughterhouses in clean districts at present in Kenya



Annex 13: Cattle movement for slaughter countrywide within Kenya, 1989-1997

District	1989	1990	1991	1992	1993	1994	1995	1996	1997	Annual average
Garissa	24595	52261	54019	71699	30702	30710	68114	75780	74023	53545
Narok		13804	16579	8175	39045	33817	39527	28375	22890	25277
Kajiado	10711	9902	29668	26480	25414	33333	24741	12850	6006	19901
Laikipia			18853	15696	25842	15746	11855	11774		16628
Marsabit	0	22717	11817	8375	6290	9970	14857	38839	3245	12901
Mwingi					12432				12957	12695
S/nyanza	10406	10572	9255							10078
T/river	10129	19857	6708	10766		2994	2235	9256		8849
Nandi	14910	10839	3502	5703	11385	5272	8340	11010	8561	8836
Machakos	3726	9056	14972	19817	12017		112	3539	2811	8256
Isiolo	5389	12801	9414	9651	6774	2460	3310	7358	9878	7448
U/gishu	12253	10490	7718	3028	10786	2977	4013		1890	6644
Samburu	3489	7606	7990	11368		731	3748	8210	8830	6497
Migori					536	16185	4934	801		5614
Mandera	8588	10290	4588	6675	4834	3052	1305	86		4927
Nakuru	3072		8840	5735	3767	3013	2889	3320	8533	4896
Kuria						32	14581	43		4885
Bomet				3039		8045	0	6295	4468	4369
Baringo		2530	1244	2151	10672	4298	1784	3261	3724	3708
Koibatek							5700	1585		3643
W/pokot	125	1897	124	5661	4332	4769	5463	3621	2861	3206
Kitui	3179	5937	3482	6447	2087	0	1022	0	4853	3001
Lamu	3598	5217	824	6796	3715	1443	0	1666		2907
Nyandarua	1794	3509			4742		3119	1793	1544	2750
Bungoma	6531	6460	210	2353	1201	379	681	1873	3158	2538
Wajir	7126	1776	1275	4418	1712	179	2917	942	1732	2453
T/nzoia	2342	3840	1521	3371	2718	974	3385	2210	511	2319
Kericho	2077					1122	582	1380	3406	1713
T/nithi				101	102		3865	2892	1222	1636
Kisumu	4060	2553	28	76		1306	1708			1622
Marakwet		1615	549				2757	1489	1595	1601
Keiyo	3935	439	4333	1713		115	71	26	45	1335
Turkana	1157	903	2660	2415	973	165	205	1246		1216
Kilifi	1055	817	2310	2542		248		6		1163
Kiambu	1507	2452	1309	350	234	0	176		138	771
Embu		129	4845	35	599	344	29	77	0	757
T/taveta	0	2500	0					345		711
T/mara						422		356		389
Kisii				477	163		40	600		320
Nyamira				19		532	563	157		318
Siaya		25	65	60	92	1452	68	18		254
Nyeri	253	0	0	0	0	685	0		846	223
Mt.elgon						10	373		0	128
Thika							10	197	143	117
Muranga	10	46	93	185	507	0	7	0	0	94

Mombasa	13	5	24	287			0	229		93
Vihiga				57						57
Busia	233		49	0	41	33	82	0	0	55
Kwale	49	86		0		0				34
Kirinyaga	169	23	0	0	0	8	2	1		25
Meru	0	18	0			0	2	0	0	3

Annex 14: Cattle exports for slaughter to Dagoretti complex in Kenya, 1991-1998

District	1991	1992	1993	1994	1995	1997	1998	Annual average
Narok	8985	2461	3702	22267	5561	23350	23294	12803
Kajiado	21949	10071	6424	13665	4474	5534	5183	9614
Marsabit	4140	6322	8449	2909	1996	410	371	3514
Garissa	3838	6147	6147	305	233	982	365	2574
Laikipia	4536	813	2106	1987	1281	2761	2447	2276
Kuria	0	0	0	2010	86	9042	810	1707
Nakuru	2835	1163	2058	1556	510	1697	1013	1547
Mwingi	40	20	0	3028	385	4346	2057	1411
Samburu	1039	808	1467	370	1038	2900	2083	1386
Migori	0	19	17	6286	1358	282	145	1158
Bomet	0	570	1667	3787	816	779	460	1154
Kericho	2895	230	326	2482	506	1030	313	1112
Isiolo	1695	497	774	792	569	1960	1258	1078
Machakos	5889	251	192	502	36	130	117	1017
W/pokot	1468	343	74	2287	746	385	590	842
Turkana	1153	1190	299	145	164	1982	607	791
U/gishu	485	151	17	1758	833	1371	303	703
Kitui	1094	1375	1813	79	68	37	10	639
Kibiko	4148	0	0	0	0	0	0	593
Unknown	0	304	593	359	52	140	929	340
Mandera	84	614	557	545	70	310	0	311
Nyandarua	456	158	186	277	6	141	23	178
T/nzoia	318	36	19	180	114	96	456	174
Wajir	36	199	706	63	0	65	0	153
Nandi	0	19	0	142	90	453	153	122
Baringo	0	0	139	360	222	0	18	106
Kisii	244	57	0	240	20	0	0	80
Koibatek	0	0	0	0	0	448	99	78
Transmara	0	0	0	0	0	365	144	73
Nairobi	218	1	2	135	4	61	0	60
Meru	61	255	19	0	20	16	19	56
Kiambu	180	43	72	68	5	1	0	53
Tanzania	0	0	0	0	0	344	0	49
h/bay	0	0	0	202	0	0	0	29
Kakamega	0	0	17	43	121	0	21	29
Marakwet	0	0	0	29	91	43	0	23
Nyambene	0	0	0	0	0	159	0	23

Makueni	0	15	20	40	33	30	0	20
Nyanza	91	23	19	0	0	0	0	19
Nyeri	0	0	0	34	92	0	0	18
T/river	0	0	91	0	0	0	34	18
T/nithi	0	0	94	0	0	0	0	13
Lugari	0	0	0	0	0	37	52	13
Embu	40	0	42	0	0	0	0	12
Nyamira	25	0	0	0	0	0	20	6
Kisumu	0	40	0	0	0	0	0	6
Muranga	0	0	22	0	0	18	0	6
T/taveta	0	0	0	0	0	40	0	6
Thika	0	0	0	15	2	20	0	5
Bungoma	21	0	0	0	0	0	0	3
Lamu	0	15	0	0	0	0	0	2
Mbeere	0	0	0	0	0	0	6	1

Annex 15: Indigenous terminology for CBPP, Kenya

District	Tribe	Name	Meaning
Tanariver	Wardei Somali Orma	*Berfur* *Sambap* *Somba*	Lung Lung Lung
Narok	Maasai	*Olkipiei*	Lung
Kajiado	Maasai	*Olkipiei* *Mavui*	Lung Lung
Mwingi	Akamba	*Mavui ma* *Ngombe* *Mavui* *Mavui na Itema*	Ox lung Lung Lung and gallbladder
Makueni	Akamba	*Mavui* *Mavui*	Lung Lung
Thika	Kikuyu	*Murimu wa* *mahuri ma* *Ngombe*	Ox lung
Kiambu	Kikuyu	*Mahuri wa* *mahuri ma* *Ngombe* *Murimu wa* *mahuri*	Ox lung disease Lung disease
Nairobi	Kikuyu	*Murimu wa* *mahuri Mavui* *ma Ngombe* *Mavui* *Thofof*	Lung disease Ox lung Lung

Table16: Cattle population estimates in Kenya, 1989-1998

District	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Bungoma	351000	367400	344900	316000	344400	287900	287600	288820	290830	
Busia	168000	173600	174300	183400	181900	189500	189500	122370	124190	128120
Garissa	605000	600000	650000	130000	375400	400000	150300	650000	334500	367840
Isiolo	181000	199000	219000	175000	193500	101400	101400	210000		
Kajiado	727700	633500	806000	646000	956400	842700	809700	568730	806200	683810
Kiambu	179400	181800	172900	171900	177100	124100	124100	123950		
Kilifi	208200	227600	207300	208000	223300	209100	209100	250250	150110	151730
Kitui	336000	376000	394000	386000	165700	190800	190800	219640		
Laikipia	267300	279000	272700	263000	512300	233200	233300	241800	256500	274240
Lamu	48000	28000	28000	30000	31500	33500	33500	38400		38400
Machakos	519600	526600	519000	231100	280100	324500	294500	284720	303690	
Makueni	-	-	-	206500	208200	247500	247200	386000		
Mandera	151000	143000	129900	650000	171600	105800	400000	185650	162870	203590
Marsabit	375000	394000	354000	196500	152400	156000	156000	224500		
Mwingi	-	-	-	-	239100	162800	162800	165570		
Nairobi	13650	18890	18430	21380	26330	21600	21600			
Nakuru	445900	459700	447000	417600	351100	399700	419700	504380	344020	342280
Narok	139800	902000	908000	899000	931300	532300	532300	680190	606350	
Nyandarua	250100	263400	262900	272100	270400	268400	268400	266760	266290	533050
Samburu	177100	190800	199000	119800	121700	312900	312900	122820	185970	223170
Taitataveta	170800	141500	142000	145500	145500	160500	160500	158530	144500	115150
Tanariver	521000	547000	585000	584000	480800	490000	490000			342600
Thika	-	-	-	-	-	-	54200	107050		107050
Transmara	-	-	-							
Turkana	313000	419000	419500	223000	153400	165000	165000	179120	240000	240000
Wajir	265000	322000	320000	160000	278500	286800	256300	160000	239250	234460
Westpokot	214500	219000	231000	223300	222800	232900	232900	217600	231400	
Total	6628050	7612790	7804830	6859080	7194730	6478900	6503600	6356850	4686670	3985490

Source: Kenya Ministry of Agriculture, Animal production Department
Blank =cattle population estimates not available
- =district did not exist

Annex 17: CBPP vaccination figures, Kenya, 1989-1998

District	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Bungoma	0	9013	0	0	0	0	0	0	0	0
Busia	29354	15654	0	0	0	0	0	0	0	0
Garissa	286941	248000	170320	133540	140682	59000	134122	152730	45949	149307
Isiolo	0	47724	80549	6691	88148	145884	73149	30982	90599	110998
Kajiado	0	0	23222	0	50384	45428	48350	14700	197764	21867
Kiambu	0	0	0	2181	1342	0	0	1200	3518	0
Kilifi	6000	0	0	0	0	0	0	0	0	0
Kitui	84277	47000	92757	51130	99702	24848	45118	34002	4550	0
Laikipia	0	0	0	6000	2450	24050	4000	200	10000	0
Lamu	19714	23984	22541	21000	0	10000	18763	19584	0	27290
Machakos	0	0	0	20100	0	0	11203	0	0	0
Makueni				0	0	23199	27340	12591	14049	0
Mandera	0	25111	39430	29495	27400	110370	80134	0	0	0
Marsabit	62492	90920	36641	102517	99493	129330	180021	96278	153373	4002
Mwingi					24224	33680	12809	12179	41212	23998
Nairobi	0	0	0	0	1500	7500	0	2800	0	0
Nakuru	0	0	0	11700	3000	10000	5450	14700	2600	303
Narok	0	102829	271089	414250	339820	205850	338421	121271	29160	110500
Nyandarua	0	0	0	0	8060	0	0	0	0	0
Samburu	0	0	0	0	0	30100	77606	96358	0	0
Taitataveta	10000	0	0	0	0	0	0	0	0	0
Tanariver	205088	165066	200032	168241	205614	173958	170664	202683	124282	59054
Thika							0	4500	1970	2980
Transmara						152568	253911	2150	210209	0
Turkana	41893	96000	1210	35818	13714	27775	34948	58709	0	59638
Wajir	27931	32000	48292	47540	122690	106330	63859	0	25820	200459
Westpokot	91009	55281	86999	59343	28419	113847	150820	87773	81696	48655

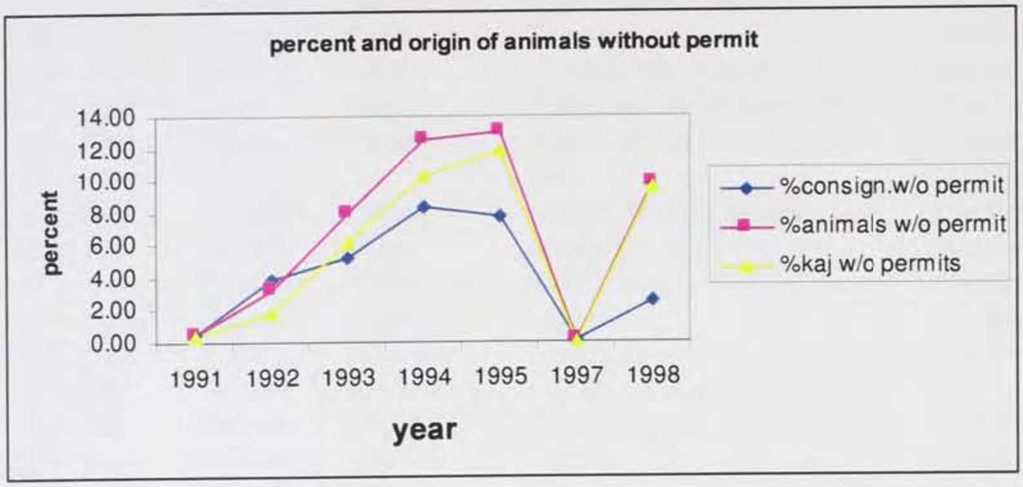
Source: Kenya Ministry of Agriculture, Veterinary Department

Annex 18: CBPP vaccine distribution and use in Kenya , 1989-1998

Year	Vaccine distributed	Vaccine used
1989	1176600	864699
1990	772600	958582
1991	2512200	1073082
1992	1291070	1121246
1993	1523450	1269084
1994	2049425	1563886
1995	1305750	1718090
1996	1204300	965408
1997	1540750	1107319
1998	608200	819047

Source: Kenya Ministry of Agriculture, Veterinary Department

Annex 19: Proportion of cattle moved without permits to Dagoretti slaughterhouse, Kenya, 1989-1998



Annex 20: Relationship between vaccine used and number of outbreaks, Kenya, 1989-1998

Annex 21: CBPP outbreaks, Kenya, 1989-1998

Year	Month	Province	District	Location	Status
1989	Dec	Central	Kirinyaga	Marurumo (Mwea)	Confirmed
1989	Nov.	Coast	Kilifi	Kambu Loc.	Confirmed
1989	Nov.	Coast	Kilifi	Uwanja Wa Ndege	Confirmed
1989	June	Coast	Lamu	Kibokoni (Witu Division)	Confirmed
1989	Nov.	Eastern	Embu	Embu Mwea Ranch Karaba Loc.	Confirmed
1989	Nov.	Eastern	Embu	Ishiara Market Evurore Loc.	Confirmed
1989	Jan.	Eastern	Kitui	Mutomo	Confirmed
1989	Jan.	Eastern	Machakos	N.Y.S Yatta	Confirmed
1989	Jan.	Eastern	Machakos	Embakasi	Confirmed
1989	Jan.	Eastern	Machakos	Lukenya	Confirmed
1989	Jan.	Eastern	Machakos	Boming Range	Confirmed
1989	Jul.	Eastern	Meru	Lewa Downs	Confirmed
1989	May	N/Eastern	Garissa	Sankuri	Confirmed
1989	March	Riftvalley	Nakuru	Mai Mahiu (Naivasha)	Confirmed
1989	Nov.	Riftvalley	Narok	Ndarakwa	Confirmed
1989	March	Riftvalley	Turkana		Confirmed
1990	Sept.	Central	Kiambu	Karai	Confirmed
1990	Sept.	Central	Kiambu	Ndeiya	Confirmed
1990	June	Coast	Kilifi	Galana Ranch	Confirmed
1990	Feb.	Coast	Kilifi	Mariakani APRS	Confirmed
1990	Nov.	Coast	Lamu	Nairobi Ranch (Kipini)	Confirmed
1990	Aug.	Eastern	Kitui	Mutomo And Entire District	Confirmed
1990	Jan.	N/Eastern	Garissa	Sankuri	Confirmed
1990	Dec	Riftvalley	Kajiado	Ongata Rongai	Suspected
1990	March	Riftvalley	Narok	Elangata Nterit (Naroosura Loc.)	Confirmed
1990	April	Riftvalley	Narok	Narok G.K Prison	Confirmed
1990	March	Riftvalley	Narok	Loita Loc.(Olduroto Village)	Confirmed
1990	April	Riftvalley	Narok	Naikara Loc.	Confirmed
1990	April	Riftvalley	Narok	Sandy River	Confirmed
1990	April	Riftvalley	Narok	Megwara	Confirmed
1990	April	Riftvalley	Narok	Aitong	Confirmed
1990	April	Riftvalley	Narok	Olkinyei	Confirmed
1990	April	Riftvalley	Narok	Ntuka	Confirmed
1990	Jan.	Riftvalley	Narok	Olposimoru Loc.	Confirmed
1990	June	Riftvalley	Samburu	Wamba	Confirmed
1990	Jul.	Riftvalley	Samburu	Lodung'okwe	Confirmed
1990	Jul.	Riftvalley	Samburu	Swari	Confirmed
1991	Aug.	Central	Kiambu	Ndeiya	Confirmed
1991	Aug.	Central	Kiambu	Karai	Confirmed
1991	June	Coast	Kilifi	Malindi(Kaloleni Div.)	Confirmed
1991	Nov.	Coast	Kilifi	ADC Kiswani Complex	Confirmed
1991	Feb.	Coast	Kilifi	Galana Cattle Company	Confirmed
1991	Jul.	Coast	Kilifi	Mariakani APRS	Confirmed
1991		Coast	Kilifi		Confirmed

1991	June	Coast	Lamu	Kipini	Confirmed
1991		Coast	Mombasa		Confirmed
1991	Jul.	Coast	Taita Taveta	Taita Ranch(Voi Division)	Confirmed
1991	Jul.	Coast	Taita Taveta	Maungu Ranch	Confirmed
1991	Jul.	Coast	Tanariver	Garsen	Confirmed
1991	Aug.	Coast	Tanariver	Wenje	Confirmed
1991	Jan.	Eastern	Kitui	Kyuso	Suspected
1991	Jan.	Eastern	Machakos	Makueni Div.	Confirmed
1991		N/Eastern	Mandera		Suspected
1991	Jul.	Riftvalley	Kajiado	Saikeri,Ngong	Suspected
1991	Jan.	Riftvalley	Kajiado	Ongata Rongai	Confirmed
1991		Riftvalley	Laikipia	Kimuri Farm	Confirmed
1991	Jan.	Riftvalley	Nakuru	Marula Estate (Naivasha)	Confirmed
1991	Jan.	Riftvalley	Nakuru	Gilgil Div.	Confirmed
1991	Jan.	Riftvalley	Narok	Oletukat(Illdamat Loc. East Mau Div.)	Confirmed
1991	Jan.	Riftvalley	Narok	Lasit(Kekonyokie Loc. East Mau Div.)	Confirmed
1991	Aug.	Riftvalley	Narok	Lolgorien Div.	Confirmed
1991	Dec	Riftvalley	Narok	Emarti	Confirmed
1991	April	Riftvalley	Narok	Masandare(Ewaso Nyiro Osupuko Div.)	Confirmed
1991	Sept.	Riftvalley	Narok	Enkutoto	Confirmed
1991	Jan.	Riftvalley	Narok	Nkareta	Confirmed
1991	Jan.	Riftvalley	Narok	Suswa	Confirmed
1991	March	Riftvalley	Turkana	Todenyang	Confirmed
1991	March	Riftvalley	Turkana	Nakana	Confirmed
1991	March	Riftvalley	Turkana	Kokuro	Confirmed
1991	Feb.	Riftvalley	Turkana	Lokitaung	Confirmed
1992	Jan.	Central	Kiambu	Ndeiya	Confirmed
1992	Aug.	Coast	Kilifi	Galana Ranch	Confirmed
1992	June	Coast	Kilifi	ADC Kiswani Complex	Confirmed
1992	Jan.	Coast	Kilifi	Galana Ranch	Confirmed
1992	Oct.	Coast	Kilifi	Kurawa	Confirmed
1992	Feb.	Coast	Kilifi	ADC Kulalu	Confirmed
1992	Aug.	Coast	Mombasa	Kibarani Dairies(Changamwe Div.)	Confirmed
1992	April	Eastern	Machakos	Machakos Ranching	Confirmed
1992	Sept.	Eastern	Machakos	Wote	Confirmed
1992	Feb.	Eastern	Machakos	Muusini (Kathonzweni Loc.)	Confirmed
1992		Eastern	Marsabit	Laisamis	Suspected
1992	April	Nairobi	Nairobi	Embakasi	Confirmed
1992	May	Riftvalley	Kajiado	Emali	Confirmed
1992	Jul.	Riftvalley	Laikipia	Ereri Ranch(Nanyuki)	Confirmed
1992	March	Riftvalley	Nakuru	Kedong Ranch	Confirmed
1992	Jan.	Riftvalley	Narok	Transmara Div And Entire District	Confirmed
1992	Jul.	Riftvalley	W/Pokot	Alale	Suspected
1993	Sept.	Central	Nyandarua	Ol Kalou Div.	Confirmed
1993		Coast	Kilifi		Confirmed

1993		Coast	Mombasa		Confirmed
1993	Sept.	Coast	Tanariver	Garsen	Suspected
1993	Jul.	Eastern	Embu	Kiambere Loc. Gachoka Div	Confirmed
1993	Jul.	Eastern	Embu	Muninji Loc. Siakago Div	Confirmed
1993	Dec	Eastern	Isiolo	Isiolo	Confirmed
1993	April	N/Eastern	Mandera		Suspected
1993	Feb.	Riftvalley	Kajiado	Ngong	Confirmed
1993	Feb.	Riftvalley	Kajiado	Mashuru(Central Kaptiei)	Confirmed
1993	Jul.	Riftvalley	Laikipia	Laikipia Airbase(Nanyuki)	Confirmed
1993	Jul.	Riftvalley	Narok	Ololulunga	Suspected
1993	Jan.	Riftvalley	Narok	Entoltol	Confirmed
1993	Jan.	Riftvalley	Narok	Mosiro	Confirmed
1993	April	Riftvalley	Narok	Kilgoris	Confirmed
1993	May	Riftvalley	Narok	Emarti	Confirmed
1993	Jan.	Riftvalley	Narok	Olposimoru Loc.	Confirmed
1993	Jan.	Riftvalley	Narok	Olduroto(Ndarakwa)	Confirmed
1993	Jan.	Riftvalley	Narok	Suswa	Confirmed
1993	Feb.	Riftvalley	Narok	Lemek	Suspected
1993	Aug.	Riftvalley	Turkana	Kakuma	Confirmed
1993	Aug.	Riftvalley	Turkana	Lokitaung	Confirmed
1994		Coast	Lamu	Mkunubi Subloc.	Confirmed
1994	April	Eastern	Kitui	Kyuso	Suspected
1994	Sept.	Eastern	Machakos	Athiriver	Confirmed
1994	May	Eastern	Machakos	Kabati	Confirmed
1994	May	Eastern	Machakos	Yatta B2	Confirmed
1994	Oct.	Eastern	Machakos	Matungulu	Confirmed
1994	Jul.	Eastern	Machakos	Komarock	Confirmed
1994	Sept.	Eastern	Makueni	Mavindini	Confirmed
1994	Nov.	Eastern	Makueni	Ithiba	Suspected
1994	June	Eastern	Makueni	Nzai Ranch	Suspected
1994	Aug.	Eastern	Makueni	Matiliku	Suspected
1994	May	Eastern	Marsabit	Moyale	Suspected
1994	Jan.	N/Eastern	Garissa	Kotile	Confirmed
1994	Jan.	N/Eastern	Garissa	Kulani	Confirmed
1994	Jan.	N/Eastern	Garissa	Liboi	Confirmed
1994	March	N/Eastern	Mandera	Ashabito	Suspected
1994	May	N/Eastern	Wajir		Suspected
1994	April	Riftvalley	Kajiado	Kitengela	Confirmed
1994	June	Riftvalley	Laikipia	Withare(Sirima Loc. Lamuria Div	Confirmed
1994	Aug.	Riftvalley	Laikipia	Ngobit Estate	Confirmed
1994	May	Riftvalley	Narok	Ololulunga	Confirmed
1994	April	Riftvalley	Narok	Olderkesi(Naroosura Loc.)	Confirmed
1994	June	Riftvalley	Narok	Enkoireroi(Naroosura Loc.)	Confirmed
1994	Jul.	Riftvalley	Samburu	Kirisia	Confirmed
1994	Jul.	Riftvalley	Samburu	Loroki	Confirmed
1994	March	Riftvalley	Transmara	Imeshuki (Kilgoris Div.)	Confirmed
1994	May	Riftvalley	Transmara	Olosheti (Lolgorien Div.)	Confirmed
1994	May	Riftvalley	Transmara	Moita (Keiyan Div.)	Confirmed
1994	March	Riftvalley	Turkana	Lokitaung	Confirmed

1995	Oct.	Eastern	Machakos	Komarock	Confirmed
1995	June	N/Eastern	Garissa	Kotile	Confirmed
1995	June	N/Eastern	Garissa	Korisa	Confirmed
1995	Nov.	N/Eastern	Garissa	Hara	Confirmed
1995	June	N/Eastern	Wajir	Leheley	Suspected
1995		Riftvalley	Kajiado	Mashuru	Confirmed
1995	June	Riftvalley	Kajiado	Ewaso Kedong	Suspected
1995	May	Riftvalley	Kajiado	Ngong	Suspected
1995	May	Riftvalley	Nakuru	Gilgil Div.	Confirmed
1995	Jan.	Riftvalley	Narok	Melelo (Ololulunga)	Suspected
1995	March	Riftvalley	Narok	Olongira (Ololulunga)	Confirmed
1995	March	Riftvalley	Narok	Transmara Div.	Confirmed
1995	Jan.	Riftvalley	Narok	Mulot(Naroosura)	Confirmed
1995	Jan.	Riftvalley	Narok	Olkinyei	Confirmed
1995	Jul.	Riftvalley	Samburu	Waso(Archer's Post)	Confirmed
1995	June	Riftvalley	Transmara	Masurura (Koiyan Div.)	Confirmed
1996	Jan.	Eastern	Isiolo	Ngare Ndare	Confirmed
1996		Eastern	Kitui	Central Div(Kyuso)	Suspected
1996	March	Eastern	Mwingi	Nguni	Suspected
1996	June	N/Eastern	Garissa	Ijara	Confirmed
1996	June	N/Eastern	Garissa	Hulugho	Confirmed
1996	Aug.	N/Eastern	Garissa	Masalani	Confirmed
1996	Aug.	N/Eastern	Garissa	Sankuri	Confirmed
1996	May	N/Eastern	Wajir		Suspected
1996	Jan.	Riftvalley	Nakuru	Mai Mahiu(Naivasha)	Confirmed
1996	June	Riftvalley	Narok	Ololulunga	Confirmed
1996	June	Riftvalley	Transmara	Sitoka	Confirmed
1996	June	Riftvalley	Turkana	Lokiriama	Confirmed
1996	Jul.	Riftvalley	Turkana	Kokuro	Confirmed
1996	Jul.	Riftvalley	Turkana	Loima	Confirmed
1997	May	Central	Thika	Ruiru	Confirmed
1997	Jul.	Coast	Kilifi	Galana Ranch	Confirmed
1997	Sept.	Eastern	Machakos	Kathekani Ranch	Confirmed
1997	Jul.	Eastern	Machakos	Lukenya	Confirmed
1997	Sept.	Eastern	Marsabit	Laisamis	Suspected
1997	June	Eastern	Mwingi	Kalitini Loc.	Suspected
1997	Feb.	N/Eastern	Garissa	Sankuri	Confirmed
1997	Feb.	Riftvalley	Narok	Mulot(Naroosura)	Confirmed
1997	Jul.	Riftvalley	Turkana		Confirmed
1997	May	Western	Bungoma	S.Kadunyi	Confirmed
1998	March	Central	Thika	Ruiru	Confirmed
1998	March	Central	Thika	Thika	Confirmed
1998	March	Coast	Taita Taveta	Voi	Suspected
1998	April	N/Eastern	Wajir	Dif	Suspected
1998	April	N/Eastern	Wajir	Sarf(Giriftu)	Suspected
1998	April	N/Eastern	Wajir	Habaswein	Suspected
1998	March	Riftvalley	Kajiado	Namanga	Confirmed
1998	Jan.	Riftvalley	Kajiado	Mbirikani(Loitoktok)	Suspected
1998	Jan.	Riftvalley	Narok	East Mau	Confirmed
1998	Feb.	Riftvalley	Narok	Talek	Suspected

1998	May	Riftvalley	Narok	Olderkesi(Naroosura Loc. Mara Div.)	Confirmed
1998	May	Riftvalley	Narok	Olortet Loc. Loita Div.)	Confirmed
1998	Jul.	Riftvalley	W/Pokot	Kacheliba/Uganda Border	Suspected

9.0 CURRICULUM VITAE

Name: Salome Wanjira Kairu Wanyoike.

Date Of Birth: 20th September, 1962.

Nationality: Kenyan.

Marital Status: Married.

Children: 3 aged 13yrs, 12yrs And 8yrs

Religion: Christian

Denomination: Presbyterian

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Fax 00 254 2 631273

Home and Permanent Contact: P.O. Box 319 Uthiru - Kenya
Tel. 00 254 2 630190

Educational background:

1969 - 1975: Madaraka Primary School, P.O. Box 506, Thika

Certificate of Primary Education

1976 - 1979: St. Anne's Secondary School, P.O. Box 270 Kiambu, Kenya
'O' Level - Division 1

1980 - 1981: Alliance Girls High School, P.O. Box 109 Kikuyu, Kenya

'A' Level - 3 Principals
- 2 Sudsidiaries

Jan. 1982 - Sept. 1983: Teaching of science subjects at Ng'enda Secondary school and attendance of tailoring course for 6 months while waiting to enter University.

Oct. 1983 - Jun. 1987: University of Nairobi, P.O. Box 30197 Nairobi, Kenya

Degree of Bachelor of Veterinary Medicine

Courses attended:

6th - 24th Sept. 1993: Regional Training Course on The Use of Immunoassays and DNA Probes For Animal Disease Diagnosis and Control. - Regional Veterinary Laboratory, Accra, Ghana

1st - 8th July 1995:	Computer course on Microsoft Windows - Kenya Agricultural Research Institute-(K.A.R.I), Muguga, Kenya.
6th Oct. - 12th Dec. 1997:	Veterinary Epidemiology and Economics and Laboratory Management - Veterinary Epidemiology and Economics Unit - University of Reading - UK.

Work experience:

14TH JULY 1987 - 1989

Central Veterinary Laboratory, Kabete, Nairobi, Kenya (Ministry of Livestock Development)

- Orientation in laboratory diagnosis, laboratory administration and practical guidance to scientists, students and other parties visiting the laboratory.

1989 - 1990

Central Veterinary Laboratory (under secondment to K.A.R.I - Ministry of Research, Science and Technology)

- Serological diagnosis of Contagious Bovine
- Pleuropneumonia(CBPP), Johne's disease, Brucellosis, Vibriosis and Trichomoniasis.
- Officer- in- charge of serology subsection of Bacteriology laboratory - General laboratory administration and supervision of 8 technical staff and 5 support staff.

1991 - 1993

Central Veterinary Laboratory (Ministry of Agriculture, Livestock Development and Marketing). Media, antigen and vaccine production and Supervision. Officer- in- charge of Media subsection of Bacteriology laboratory.

- Supervision of Higher National Diploma student at the Kenya polytechnic with a project on brucellosis in the serology laboratory.

1994 - 1995

- Officer - in - charge of serology subsection of Bacteriology laboratory.
- Writing and implementation of research proposal on the use of nuclear techniques in the diagnosis and control of CBPP and brucellosis supported by the International Atomic Energy Agency (IAEA).
- Field surveillance for Rinderpest in the Kitui and Mwingi districts of Kenya.

1996 - 1997

- Officer - in - charge of Bacteriology – laboratory. Officer - in charge of project on "The Diagnosis and Control of Animal Diseases in Kenya."
- Field and laboratory surveillance and seromonitoring for Rinderpest in the Arid and Semi- arid districts of Kenya viz. Tana River, Garissa, Lamu, Nairobi, Kajiado and Narok. Writing of research contract proposal on the

diagnosis and control of CBPP in Kenya.

- Writing of Technical Co-operation Project proposal in The use of Nuclear Techniques in the diagnosis and control of animal disease in Kenya to cover CBPP, Rinderpest, Peste de Petits Ruminants, and tick-borne diseases
- Training of staff in the use of Enzyme Linked Immunosorbent Assay(ELISA)in the diagnosis of Brucellosis and Rinderpest and results processing using the computer based EDI programme including serum banking and processing of data using the SID3 computer programme.
- Surveillance for CBPP in the Thika district of Kenya

Scientific meetings attended:

Dec. 1994	-	Annual Scientific Meeting K.A.R.I. Muguga, Kenya.
21st Feb. 1995	-	Rural Radio Project Workshop Agricultural Information Centre - Kenya
22nd - 26th Apr. 1996	-	IAEA Mission on preparation of country framework programme for technical co-operation projects. National Council for Science and Technology- Nairobi, Kenya
6th Dec. 1996	-	Kenya/Tanzania PARC harmonisation meeting. OAU/IBAR/PARC - Nairobi, Kenya
24th - 26th Mar. 1997	-	7th OAU/IBAR/PARC East African Co-ordination Meeting Machakos, Kenya - Surveillance for Rinderpest in Kenya in 1995/96 results presented.
7th - 11th Apr. 1997	-	International Symposium on Diagnosis and Control of Livestock Diseases using Nuclear and Related Techniques. "Towards Disease Control in the 21st Century" Vienna, Austria

Hobbies: - Knitting
Reading
Visiting

Signed Declaration Sheet

I the under signed, declare that this thesis is my original work and has not been presented for a degree in any university.

Name SALOME W. WANYOIKE

Signature [signature]

Date of submission 15th November, 1999

This thesis has been submitted for examination with our approval as university advisors.

Dr. M. P. O Baumann [signature]

Dr. Fisseha Tareke [signature]