AN ECONOMIC ANALYSIS OF DAMAGES AND OTHER LOSSES CAUSED BY TICKS AND TICK-BORNE DISEASES, PARTICULARLY IN RELATION TO EAST COAST FEVER (ECF)

BY

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This Research Paper is my original work and has not been presented for a degree in another University.

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This Research Paper has been submitted for Examination with our approval as University Supervisors.

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ABSTRACT

Ticks and Tick-borne diseases are a major impediment to the development of the livestock sector in Kenya. They cause significant production losses through mortality, impair productivity of surviving animals, and discourage the genetic improvement of cattle in the high potential areas. Of the tick-borne diseases, ECF is the most important. No vaccine or drug has been adopted for widespread field use against the disease, and its control relies on the application of acaricides on animals to control the tick population. Indigenous cattle in endemic areas have developed partial immunity to the main tick-borne diseases. It is the genetically improved cattle that are most susceptible to the diseases.

Despite a long period of tick-control (starting in the early 1900s), losses from tick-borne diseases, particularly ECF, are still high. This preliminary study attempts to analyse the economic factors that influence farmers decisions to undertake tick-control and abate damages and losses from tick-borne diseases, particularly ECF.

In Chapter Three, we note that an economic problem exists in the farmer allocation of resources to tick control. Various factors cause a divergence between the social and private benefits from control. They include significant externalities, risk, economies of scale and indivisibilities of tick control facilities, and farmer ignorance. Government involvement was found essential to induce a more optimal

allocation of resources to tick control. The implications for the financing of the government involvement are also discussed.

In Chapter Four, econometric analysis is undertaken to gauge the impact tick parameters have on cattle breed portfolio and farmer participation in tick control in various regions of the country. This is analysed in a wider context, incorporating such factors as the land potential and adjudication. The parameters, particularly the distribution of cattle dips and spray races, are found to have a high 'explanatory' power. Policy implications are then discussed.

In Chapter Five, we find that in a cost-benefit framework, tick control is to a large extent a viable investment to farmers and to society. The magnitude of benefits, however, was found to depend significantly on the assumption made on the level of cattle improvement adopted. The net benefits are only marginal when no genetic improvement is postulated, and are even negative when farmers apply individual spraying - the more expensive method of control.

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CHAPTER ONE

INTRODUCTION

1.1: Scope of the Study

This paper will analyse the problem of ticks and tick-borne diseases in Kenya, but incorporating information from elsewhere. The major emphasis is on cattle tick-borne diseases. This means that one of the economically important tick-borne diseases, the Nairobi Sheep Disease, will be left from the analysis. Another delimitation, and as the title of the paper indicates, is that emphasis is on East Coast Fever (ECF), the most important cattle tick-borne disease, in terms of the economic losses caused to the livestock sector in Kenya, and several other countries. This disease is caused by a protozoa, Theileria Parva, and transmitted by a three-stage tick vector, Rhipicephalus Appendiculatus (R.App.). The tick's main predilection site is the ears, so that it is alternatively called the Brown Ear Tick.

Other cattle tick-borne diseases of economic importance in Kenya are anaplasmosis, redwater (babesiosis) and heartwater. Anaplasmosis and redwater are transmitted mainly by a one-stage tick, Boophilus decoloratus, while heartwater is transmitted by the tick, Amblyomma Variegatum.

1.2: Distribution of Ticks and Tick-Borne Diseases

Ticks and the diseases they transmit are widely distributed over the world, and act as a major impediment to livestock development in many countries.

As one study aptly states:

> of all external parasites, ticks cause the greatest economic losses in livestock in the world today .... with about three quarters /of the world cattle population/ in tick-infested habitats ...[1]

In East Africa, the 1967 FAO Livestock Survey termed them as the "single largest impediment to livestock sector development ---" Elsewhere in Africa, ECF has been reported from Mozambique, South Africa, Zaire, Rwanda, Burundi, Malawi and the Sudan, and extending to Ethiopia, Zambia and Southern Sudan. The disease has been reportedly eradicated in South Africa and Mozambique (Bram, p.2).

The presence and abundance of ticks is influenced by a wide range of climatic and ecological factors. Of these, research done in Kenya and elsewhere show that the most important are rainfall, temperature and vegetation cover. Rainfall and humidity mostly influence the survival rate of the ticks while temperature affects the rate of development of ticks from one stage to another. Vegetation, and in particular grass cover, reduces the impact of adverse climatic conditions on ticks and is necessary for ticks to attach onto while waiting for host animals. Such animals should be frequent if the tick population is to be propagated[2].

<u>R. app.</u> requires at least 25" (635mm) of rainfall to survive. Above this critical level, the adult tick population increases proportionally to rainfall. It thrives at an altitude of less than 7000ft above sea level (Walker, p.26). Therefore, the

tick is widely distributed over the country, except for the dry North-Eastern Province, dry areas of the Rift Valley province (such as Turkana and Samburu),Eastern province (eastern parts of Meru and Embu districts) and the Coast Province (Tana and Lamu districts) as well as the regions bordering Mts. Kenya, Aberdares, Mau and Elgon (Walker,p.123). Approximately half of the national herd is found in such tick-infested areas (Duffus, p.28).

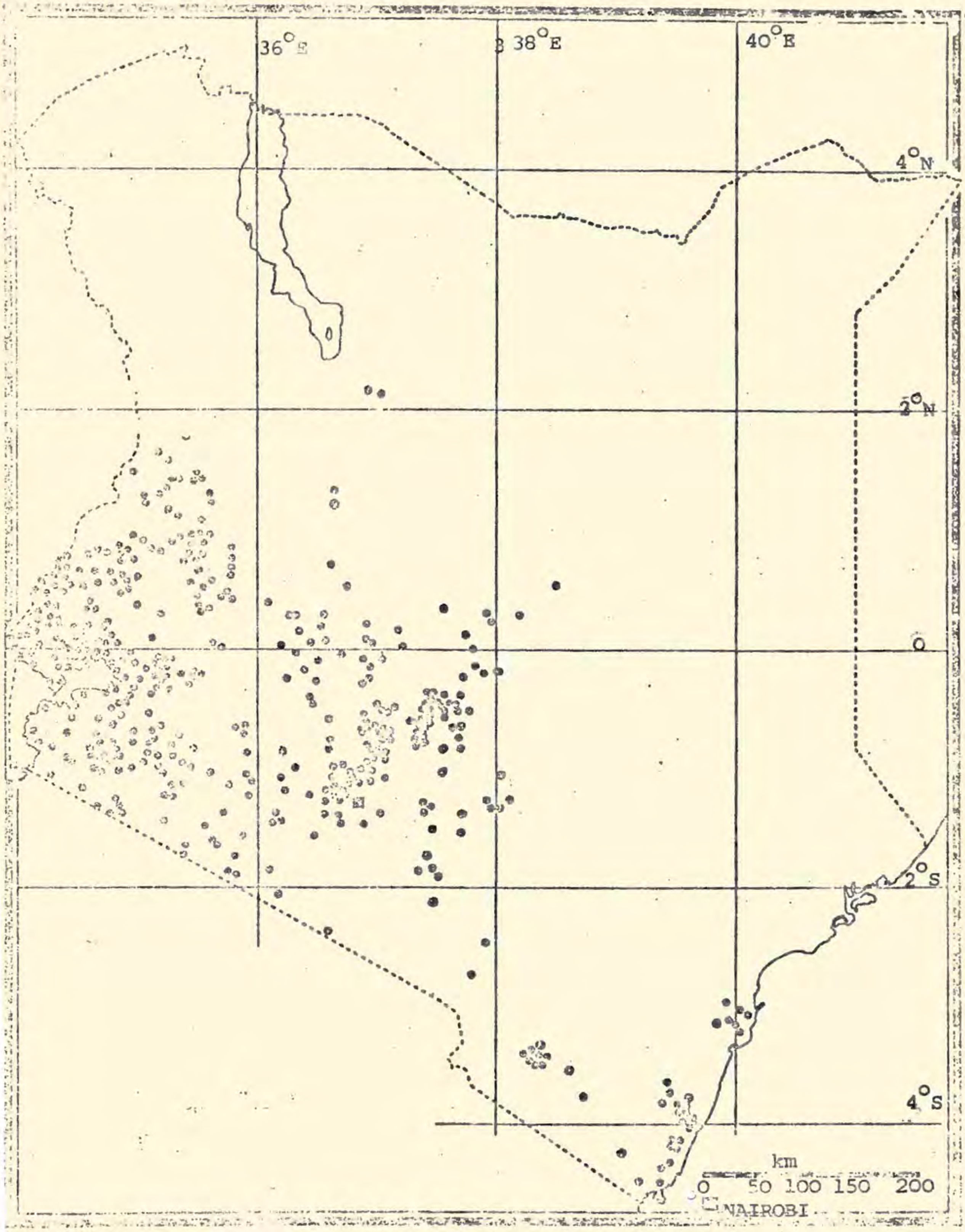
However, the distribution pattern is disturbed by tick-control. Expectedly then a FAO/UNDP survey in Kenya[3] found a wide variation in tick numbers on "undipped" cattle, more than would be explained by the aforementioned climatic and ecological factors. The survey results however indicated that every district (except the very dry Eastern and North-Eastern Provinces) experienced some tick challenge at least during the wet season, even in areas where tick control standards are high.

The ticks transmitting other diseases are more widely distributed, as they survive in drier conditions. However, they do not pose major economic problems, the disease incidence often being merely sporadic.

1.3: Economic Damages and Losses caused by Ticks and Tick-Borne Diseases.

Ticks and tick-borne diseases are economically important because they cause significant production losses in the livestock sector. These production losses take three forms-:

Map 1.1 Distribution of Rhipicephalus Appendiculatus, the Tick Vector that transmits ECF in the field.*



Source: FAO/UNDP (c), p.30.

* Based on a FAO/UNDP survey undertaken in Kenya in the early 1970s. The dots indicate the position of standardised clusters at which at least one adult R. app. was collected from "undipped" cattle. Details of this survey are presented on p.21.

1. Livestock mortality

2. Impaired productivity of some of the remaining cattle population

and 3. Opportunity cost of development that would have been motivated in the absence of ticks and tick-borne diseases in endemic areas - mainly the improvement of cattle.

Livestock Mortality

As indicated elsewhere, ECF is the major and the economically most important tick-borne disease in Kenya and several other countries. Where the disease is endemic, 10-50% of the calves are lost from it and other tick-borne diseases. For the exotic and/the susceptible indigenous cattle, the mortality rate is higher. More than 90% die when infected with the disease.

In 1977, there were about 5000 cases of ECF confirmed by microscopic diagnoses in Kenya, an almost equivalent number of anaplasmosis cases and less than a 1000 cases of redwater.

Confirmed cases constitute only a small proportion of the total number of cases, and may give a misleading picture of the extent of the tick problem. Only a few farmers identify and report death of their livestock from tick-borne diseases, there being no incentive to do so, and due to farmer ignorance and an inadequate communications network. One estimate puts the number of deaths from ECF for cattle more than one year old as ranging from 50,000 to 70,000. The estimate of the total number of calves that die from ECF and other tick-borne diseases is 100,000 calves annually (Duffus, 1976).

Table 1.1 CONFIRMED CASES OF MORTALITY FROM THE MAJOR TICK-BORNE DISEASES IN KENYA, 1977-78.

	ECF		Anaplasmosis		Redwater	
PROVINCE	1977	1978*	1977	1978*	1977	1978*
Central	1151	910	939	1012	84	31
Western	236		312	260	12	25
Nyanza	1960	1347	785	501	75	34
Coast	NA	NA	NA	NA	NA	NA
Rift-Valley	587	926	127	380	53	16
North-Eastern	-	-	-	-	-	-
Eastern	532	567	1134	2000	502	124
PARTIAL TOTAL	4766	3981	3303	4153	726	330

* Excludes calves

NA = The figures were not available

Source: Kenya. Ministry of Agriculture (MOA) Animal Production Branch. Annual Report 1978, p. 15.

Impaired Productivity of livestock.

The productivity of animals will be impaired in several ways. Tick bites cause physical damage to livestock, thereby lowering the value of hides from such animals. When the ticks feed on the udders, this may affect milk output from such animals. Tick bites are also favoured sites for development of fungal and bacterial infections, leading to abscesses. When the rate of infestation is high, the blood loss due to the feeding of ticks may lead to anaemia and, at times, death.

Calves that survive tick-borne disease infections tend to be stunted in their further growth, thus affecting their future productivity. The same applies to adult cattle. An infected animal becomes unthrifty and it may take up to 18 months before it starts gaining condition , even under good management (Oteng (1976), p.22). The stunting also reduces the resistance of the animals to other diseases.

Some types of ticks, for example R. app. , inject toxins into the animal which are believed to have debilitating effects on metabolic processes, and leading to the condition called 'toxicosis' (Barnett, p.5 ; Drummond,p.29).

However, what the farmer notes is reduced condition of his animals, resulting in lowered productivity, especially with respect to milk and weight gain. This is aggravated by the fact that the irritation of the skin diverts the attention of the animal from foraging to licking and scratching, so that compensatory feeding does not occur. When the farmer milks with the calf at foot, and it dies from tick-borne diseases, he loses a large proportion of the lactation. This is commonly the case with the indigenous cattle that tend not to "let down" their milk in the absence of the calf.

The Opportunity Cost of Discouraged Improvement of Livestock in the High and Medium Potential Areas

Farmers are reluctant or unable to improve their livestock when the improved calves are more prone to tick-borne diseases. Hopcraft (p.60) cites one estimate of the Veterinary Department of Kenya which indicates that 35% of all Artificial Insemination (AI) heifers never calve; 80% of these (or 28% of the estimated 112,000 heifer calves born in 1973) are lost from ECF and other tick-borne diseases. In such an environment, farmers prefer the less disease-prone indigenous livestock.

This state of affairs imposes a high opportunity cost to the economy. The improvement of cattle by crossing the indigenous Zebu with the exotic cattle raises milk output of the Zebu from about 200 - 400 litres to about 1300 litres. Additional matings are expected to increase milk yield by 1 to 2% every year (Ruigu, p.18). In Kenya, there is a high potential for substituting the unproductive indigenous cattle with improved cattle. About 90% of all adult female cattle are Zebu, with the exotic breeds accounting for a mere 1% of all commercial milk production in 1974 (Ruigu p.34). In the areas receiving at least 30" of rainfall, the high potential areas of Kenya, there are close to 2 million Zebu cattle.[4]

1.4: Key Elements in the Analytical Framework of Control, Particularly of ECF.

Against the above background, we should note the following salient features about the control of ECF, and other tick-borne diseases, which form the basis of subsequent analysis.

1). Possibility of Chemotherapeutic and Prophylactic Treatment

While immunisation and/or use of drugs is possible against most diseases that affect the livestock sector, including anaplasmosis, redwater and heartwater, there is as yet no vaccine (or drug) adopted for widespread field use against the major tick-borne disease, ECF. However, we note that research at Muguga, under the auspices of a FAO Regional Project set up in 1967, has recently discovered a method of immunising cattle against most strains of ECF.[5] It is an 'infection and treatment' method. The government has not yet incorporated this method in tick-control policy or programmes, probably because it may be fatal to cattle if the two components of the method are not well synchronised. It is also feared that it might induce a carrier status in cattle and is clumsy if the immunity lasts for only a short period (Cunningham, personal communication). Even for the other major tick-borne diseases, prophylactic and chemotherapeutic treatments are of minor importance at the national level (Kane, p.72).

The main method of protecting cattle from ECF and other tick borne diseases is indirect, through elimination of the tick-vectors by short-term dipping or spraying, using an appropriate acaricide. This is reinforced by hand-dressing, fencing and restriction of cattle movement. The FAO/UNDP survey mentioned earlier found that the majority of farmers used communal dips (43%) with only a small proportion using individual spraying (8.9%) while a significant proportion (30%) practiced no control at all. This probably reflected the fact that the largest proportion of animals were owned by smallholders (45%), with a smaller proportion of large-scale farmers (17%) and pastoralists (4.9%). Most of the rest were owned by cooperatives.

Dipping is both expensive and cumbersome. The building of dips involves a high initial cost, and the / dip wash needs to be changed once or twice a year and closely monitored the rest of the time to maintain the correct strength of acaricide. When animals are moved long distances to dips, production losses, especially for improved cattle are significant, not to mention the impact of large herds on the land holding the cattle dip, and along the mustering paths. This method continously faces the threat of development of tick resistance to the acaricides used. This is no doubt accelerated by poor management of the dips. In Kenya, about 50% of dip wash samples taken for testing at Kabete are found understrength. The proportion might be higher due to "doctoring" of samples before sending for testing (IDS, p.27).

Due mainly to the physical impact of presence of ticks on cattle, development of a vaccine and/or drug against ECF would not dispense with chemical control. Instead, it would reduce the rate and intensity of its use, particularly if it used in conjunction with the available prophylactic methods against anaplasmosis and babesiosis. The method for heartwater is still difficult and not yet feasible for large-scale use in the field (Uilenberg et al., p.312).

2). Differential Breed Immunity to Tick-Borne Diseases.

The indigenous cattle, mainly the Zebu, if reared in disease enzootic areas display some immunity to tick-borne diseases. Some of the immunity is inherited from the dam (Barnett, 1957) while the rest is acquired through constant exposure to the tick and disease challenge. In an ECF enzootic area, calves contract the disease in the first six months of their life. Well-fed calves recover and acquire immunity to the disease. This immunity is gradually lost from 3 - 4 years, depending on the severity of infection. Constant disease challenge ensures that this immunity is maintained in the life of the animal (Oteng (1976), p. 21).

Exotic cattle are very susceptible. An almost 100% mortality rate result when they are introduced in tick-borne diseases (particularly ECF) endemic areas. However, even for the indigenous cattle, the immunity may be overcome if cattle management is poor or when they are moved from disease free to disease enzootic zones. The enzootic zone may also extend to clean areas during the wet season. Then, the diseases take the epizootic form, resulting in heavy losses, both of calves and adult cattle. This often happens in pastoral areas in the dry season when livestock are moved to the wet ECF endemic areas in search of pasture. An example relates to Sukumaland, Tanzania. In the early 1960s, nearly half a million cattle died from ECF, when cattle were moved to the shores of Lake Victoria where the disease is endemic, from the 'clean' dry inland (FAO, 1967).

3). Need For Farmer Participation

For effective control of ticks and tick-borne diseases in an area, all the livestock within the area must be dipped or sprayed regularly in an acaricide of correct strength. This is due to high mobility of ticks, mostly on small animals but even by wind. Therefore, ticks and tick-borne diseases control require a high degree of cooperation from the farmers if it is to be successful. For example, Harmon and Zalla (1974), in an evaluation of the Vihiga Special Development programme concluded that the dip project in the area had failed in its objectives due to lack of support at the local level.

This paper argues that farmers will rationally respond favourably and voluntarily if they perceive the benefits from participating in tick control as exceeding the amount of resources that they use in the effort. Therefore, the decision to and the extent of participation in tick control is mainly in response to social and economic factors. It is then imperative to incorporate these factors in the design of a successful control policy.

1.5 Statement of the Problem

The first case of ECF in Kenya was diagnosed in 1904 (Walker, p.1). Since that time a large amount of scarce economic resources have been, and continue to be devoted to the control of ticks and tick-borne diseases, both by the state and by the livestock farmers. There were, by 1978, about 5500 completed dips and spray races in the country. They were distributed as follows:

Province	Total Number of dips in 1978
Central	1104
Rift Valley	2806
Eastern	711
Coast	134
Nyanza	225
Western	511
TOTAL	5491

Source: MOA, Animal Production Branch, 1978 Annual Report, p.15.

Over the 1971-76 period, the value of dip and spray fluids used rose from KSh.13.3 million to KSh.30.1 million, an average increase of 14.5% p.a.. On average, this constituted half the value of all chemical and medicinal inputs to the livestock sector.

Table 1.2: Value of Chemical and Medicinal Inputs to the Livestock Sector, K£'000.

	1971	1972	1973	1974	1975	1976
Dip, Spray Fluids	666	703	765	829	1,039	1,506
Vaccines	263	628	460	444	727	810
Other Livestock Drugs	223	352	263	490	557	710
Total	1152	1683	1488	1762	2321	2848

Source: Kenya Statistical Abstract 1978, p.109.

The state is also taking an increasing role in the control of tick-borne diseases. According to the 1979-83 Development Plan (p.244), the Veterinary Department will take over the maintenance of all dips in smallholder and pastoral areas (with high ECF challenges) by end of the Plan period.

Despite the enormous cost of resources devoted to tick control very little work has been done to:

1. Quantitatively assess the economic losses caused by ticks and tick-borne diseases, and particularly ECF, and to provide a justification for social and private allocation of economic resources to tick control, and

2. analyse the economic factors, apart from profitability of tick control, which influence the extent of farmers' participation in tick-control.

Such analyses are essential if we are to design appropriate policies and strategies of tick and tick-borne disease control. This is well pointed out by one study (FAO/UNDP(d),p.14)

> ...... the Kenya cattle industry has reached a point .... where tick control cannot be looked at from a strictly disease control point of view: relevant economic factors must be taken into consideration, and intensiveness of control measures, involving expense, must be carefully balanced with returns to be expected.

This paper is intended as a contribution to this major task.

1.6 Literature Review

As indicated above, livestock diseases have received little attention in the economic literature. The area of study has been dominated by biotechnical analyses undertaken by veterinarians and entomologists. However, socio-economic analyses are necessary in the design of policy, because the most basic pest control decisions by the farmers are based on economic and social factors in addition to the technical possibilities. Nonetheless, a few economic studies have been undertaken to analyse the problem of ticks and tick-borne diseases in several regions.

Ferguson (1971) presents a comprehensive study on the economics of the tick problem in Uganda. He undertakes an economic evaluation of the Uganda Tick Control Project, which was due for launching in the early 1970s. The study is set in the context of traditional livestock husbandry within a communal grazing system due to the little headway made in land enclosure and cattle improvement at the time.

The core of the analysis is the quantification of the expected impact of the Project on farmer incomes. The conclusion is that the national average increase in income of Ush. 33.60 per head in a year of full operation of the Project may not be sufficient to induce "enthusiastic support from all the farmers, but it should be sufficient to gain their support if [dipping] fees are reasonable and [dipping] centres are convenient for owners to use" [p.254]. On the national level, the Project cost was estimated at Ush. 8 on average per farmer affected.

This study, by not including the opportunity cost of discouraged improvement of cattle underestimates the benefits from the control of ticks and tick-borne diseases. He did not analyse the time flow of benefits and costs of the tick control project.

Johnson's study (1975) is an economic theoretic analysis of public policy on cattle tick control in New South Wales in Australia. He concludes that several economic factors lead to a divergence between private and social costs and benefits in tick control, and therefore advocates some level of government involvement to achieve a better allocation of resources. The level of government involvement depends on the control strategy adopted. The selected strategy should be the one with the highest returns over the cost of executing it.

Based on the above conclusion, Johnson presents a 'cost effectiveness' analysis of control vis-a-vis eradication of the cattle tick in New South Wales, Australia. The explicit assumption is that both the strategies reduce losses from ticks to negligible levels. The two policy alternatives are combined with two possible buffer zones on the border with Queensland - "the present 5-chain buffer and a '5-mile' buffer". In the buffer zone, cattle are excluded or are intensively dipped - to control tick mobility and insurgency into the state. The analysis applies the conventional capital budgeting principles. The costs of control or eradication are assumed to be borne partially by the government and the farmers.

The analysis concludes that the policy of eradication involving cattle inspection and spot eradication followed by declaration of eradication and dismantling of quarantine boundaries would, most probably, be less expensive in the long-run than continuing control. If,however,quarantive boundaries are maintained indefinitely following declaration of eradication, it would be difficult to say which would be the cheaper policy. Based on the relative cost effectiveness, the study advocates the maintenance of the 'present' buffer zones.

The Cattle Tick Commission Inquiry Report of 1973 (1975) is the outcome of an Australia-wide inquiry into the cattle tick problem. It was set to probe a deterioration of the control situation despite increasing expenditures on control, and mainly arising from occurrence of tick resistance. Its' terms of reference, among others included an analysis of the cost of cattle ticks to the livestock sector in Australia, and the possibility of tick eradication.

The report concludes that eradication is not a practical national control strategy, except in specific areas. Such areas should have adequate tick control facilities well protected against reinfestation from outside; it should be possible to muster and include all animals in the programme and justify such a programme on a cost-benefit analysis. Enough finance should be available to ensure its continuity.

The Commission estimated an annual loss of A$40 million from the cattle tick. This loss is composed of control expenditures both by the state and farmers, and production losses.

Several other livestock diseases have received attention from economists. Power and Harris (1973) apply cost-benefit analysis to two control measures in the control of the Foot-and-Mouth disease (FMD) in Britain. The control strategies considered are the "traditional slaughter policy" and "vaccination". They measure benefits as the losses the society would incur if the disease was not controlled in the country. The estimated benefits are then compared to the costs incurred in control by the alternative strategies.

The paper finds little to choose between the two control methods in terms of the estimated net present values. The net quantifiable benefits of the "slaughter strategy" exceeds that of vaccination by only 2%. However, the analysis indicates that both methods yield large net benefits if pursued over the 1969/85 period. Sensitivity analysis show that even large variations in the assumptions made in the study do not alter the relative ranking of the strategies.

Jahnke (1974) undertakes a social cost-benefit analysis of the tsetse fly and trypanosomiasis problem in Uganda.

1.7 Aims and Hypotheses of the Study.

From the previous analysis, the following objectives and hypotheses have been set for this study.

1). To quantitatively assess the magnitude of average damages and other losses caused by ticks and tick-borne diseases, particularly in relation to ECF. This is to be at the farm-level, in a tick and tick-borne disease enzootic area, and where there is no deliberate control.

The hypothesis is that the total value of losses are high enough to justify a certain level of private control and to solicit cooperation of the farmers in a tick control project. In this analysis the value of losses to the farmers will be related to the private costs of control - the dipping fees, spraying costs and the costs of mustering the animals and moving them to the tick control points.

2). To analyse the impact of several economic factors in influencing the level of control adopted by the farmers. The factors considered are, first, farmer ignorance and inability to decide rationally - in the face of complex interaction between various other diseases and environmental constraints. The second factor is the presence of risk and uncertainty, and the third, the presence of externalities in tick control. These economic factors lead to an economic justification for some level of state intervention because the private market does not motivate farmers to allocate adequate resources either in amount or in composition to tick control.

The hypothesis is that these factors have a significant impact on the farmer participation in tick control, and in the selection of cattle breed portfolio in a tick and tick-borne disease environment.

3). The paper will attempt to provide evidence as to whether or not a typical tick control project is socially viable. That is, whether the present value of expected damages and other losses from ticks and tick-borne diseases exceed the present value of the costs of alleviating the damages and losses to the society, given the present control methods, and applying shadow or accounting prices.

1.8 Methodology

Data Sources:

Due to the time constraint, the paper uses secondary data from government publications and related literature. A major source of critical data is published results of the FAO/UNDP Epizootiological Survey on Ticks and Tick-Borne Cattle Diseases. A number of its results have been cited earlier. This survey was conducted in the 1972-74 period, and covered 36 districts in Kenya. The size of the sample was 18,047 cattle. For each district about 20 clusters were selected. Each cluster had 25 cattle selected from small herds of 4 - 5 cattle in close proximity to one another. Therefore, about 500 cattle were examined in most of the districts in the sample. The characteristics of the sample, therefore, can be expected to approximate those of the national herd.

The survey collected a very wide range of data. It included information on the type of livestock farming, age, breed and sex of the cattle, proportion of owners in each district practising tick control, tick control methods and tick numbers on "undipped" (tick un-controlled) cattle. A serological IHA test on blood samples from each animal for tick-borne diseases was also conducted.

Testing the hypotheses

1). To assess the magnitude of damages and other losses caused by ticks and tick-borne diseases, a simplified herd model will be used. A nationally representative herd of 2000 cattle will be analysed over time with and without tick control. Differences in productivity with and without tick control will be used to constitute the damages and other losses caused by ticks and tick-borne diseases. The production parameters that will be considered are the differential mortality levels, milk yields and genetic improvement.

For each year and category of economic loss, the following equation will be used

$$D = Y - Y^*$$

where:

D is the expected annual damages and losses caused by ticks and tick-borne diseases,i.e.,the anticipated economic benefits of tick control

Y is the expected productivity and mortality of the herd if there are no ticks, or more appropriately, if tick control is what is generally regarded as efficient.

and Y^* is the average productivity and mortality of the herd if ticks and tick-borne diseases control is not practiced, or is removed in a disease endemic area.

The discounted value of the D's is then compared with the discounted private costs of control per animal and per average farmer, for the various control methods.

2). To test the social viability of a tick-control project, the same model herd is used. The net benefits of control, the net annual production losses avoided, will be computed as above, but then will apply the social accounting or the shadow prices, which allow for the fact that market prices do not reflect the opportunity cost of resources to the economy.

3). The methodology and the testing of the hypothesis on the impact of the earlier mentioned economic factors is presented in Chapter Four.

1.9 Plan of the Paper

The paper will take the following format:

Chapter One is the introduction and provides the general framework for subsequent analysis.

Chapter Two consider ticks and tick-borne diseases in the context of Kenya's Livestock Sector.

Chapter Three is on the policy economics of ticks and tick-borne diseases control, and analyses in more detail the factors mentioned in the second objective of the study.

Chapter Four presents an econometric analysis of the impact of the ECF challenge on cattle improvement in various regions in the country. The factors that influence the participation of farmers in tick control are also gauged.

Chapter Five undertakes a quantitative analysis of damages and other losses caused by ticks and tick-borne diseases.

Chapter Six presents the summary and conclusions of the paper.

Footnotes

1. Wellcome Research Organisation, p. 33.

2. FAO/UNDP Terminal Report P.9. . Not every entomologist agrees with the conclusions on determination of major factors influencing tick presence and abundance. Branagan (p.153) terms them as "convenient generalisations". He notes that there are a number of areas with favourable climate and ecological conditions which do not support heavy tick populations, despite continual introduction of species by stock movements. Other areas do not have favourable conditions, but yet support heavy tick populations (for example, Kajiado district in Kenya).

   Probably it is because such areas have special micro-ecological conditions divorced from the general.

3. FAO/UNDP (a). Research on Tick-borne Cattle Diseases and Tick Control: Epizootiological Survey on Tick-borne Cattle Diseases. Report prepared for the Govt of Kenya Technical Report 1, Rome, 1975.

4. Mureithi, I. E. The Role of Veterinary Services in the Development of Kenya's Livestock Industry. The Kenya Farmer, Nairobi, Feb. 1976.

5. Three strains of T.Parva have been identified and used to immunise cattle. Results obtained from field trials suggest that the cattle treated with this method will withstand natural tick challenge when this is restricted to cattle derived T.Parva. For details of the method, see Cunningham (1978, p.330).

   Uilenberg et al. (1978) presents the results of the application of the method to cattle at Pugu Holding Ground, near Dar es Salaam, Tanzania. The method conferred a high degree of protection (of between 90-100%). They conclude that the method is ready for field application.

CHAPTER TWO

THE CONTEXT OF TICK-BORNE DISEASES IN KENYA'S LIVESTOCK SECTOR

2.1: The Contribution of Livestock to the Kenyan Economy.

Kenya is predominantly an agricultural economy. Over 80 per cent of the population derive their employment and incomes in the rural areas. Agriculture also contributes substantially to exports, and is a base for both the industrial and commercial development in the economy.

Kenya is a developing country, and a main economic problem continues to be that of poverty. In 1976, the national GDP per capita was estimated at only K£103.9 at market prices. The main poverty groups are found in the rural areas, and are identified by the Fourth Development Plan (1979-83) as pastoralists, who mainly derive their livelihood from livestock, the smallholders and the landless in the rural areas. Pastoralists make up 20% of the total population. Smallholders constitute most of the other group (Plan, p.256).

The cattle population was estimated at 7.9 million in 1970, the largest proportion owned by smallholders (50.5%) and pastoralists (42.8%). Only 6.7% were owned by large-scale farmers (Peberdy,p. 24). By 1976, the cattle population is estimated to have increased to 9.7 million (Duffus , 1976).

According to the Integrated Rural Survey undertaken by the Central Bureau of Statistics in 1974/75, livestock products comprised more than 40% on average of all sales from smallholdings in all provinces, except Nyanza. The major component was net cattle sales from smallholdings except for Central Province where milk sales were a more important component. On average 50% of all agricultural output was maintained on the farm for subsistence consumption. Needless to say, livestock and livestock products are the livelihood of pastoral communities, with many pastoralists receiving over 80% of their calories from milk (Peberdy, p.15).

On the national level, the total value of production of livestock products was estimated by the Plan at K£129 million in 1976. This comprised about 26.6% of the total agricultural production. (Export crops made up 29.3% of the total).

Over the 1964-77 period, the dairy industry accounted for 29.35% of total marketed livestock and livestock products, 22-30% of total agricultural marketed output and 8-10% of the total contribution to agriculture. The livestock and livestock products account for about 8% of total exports, with the dairy industry taking 24% of total livestock exports (Ruigu et al., p.1). The per capita consumption of milk and its products is estimated by the Plan at only 47kg per head per annum.

Per capita consumption of beef is estimated at 9.2 kg. However, this proportion is expected to decline over time as a consequence of the

> limited impact of past efforts to increase beef supplies from Kenya's extended pastoral areas, the extension of cropping at the expense of grazing in much of the medium and high potential areas, and the increasing meat demand from a rapidly growing population (Plan, p.266).

From the foregoing, it is evident that investment in disease control in the livestock sector would have a wide impact on rural incomes, the distribution of income between the urban and rural areas, between various parts of the country and inter-personally, and the overall development of rural areas. Alleviation of losses from livestock diseases would increase meat and milk output, both for domestic consumption and exports, and raise the productivity of other livestock development programmes.

Much of Kenya's rural development efforts in the past were geared more towards crop production than to livestock (Peberdy, p.2), with the arid and semi-arid areas receiving "little benefits from past development programmes" (Plan, p.253)[1]. However, with limited possibilities for crop farming and crop area expansion, the livestock sector will make an increasing contribution to the economy. This is particularly so when we consider the ecological setting of the Kenyan economy. With a land area of 569,000 km^2, only about 12% of the country's agricultural land is suited for crop production. The remaining land in the absence of irrigation or water conservation is suited

> only to stock raising, at various levels of intensity, depending on rainfall and also on soil types. Land use declines to a low level on the 60 percent of Kenya's land area which can best be described as semi-desert (ILO, p.33).

In the rangeland a major problem is to raise cattle productivity and the offtake for the market. In a fragile ecological environment, cattle is the major form (store) of wealth, and the basis of subsistence and survival. Therefore pastoral farmers will tend to hold as many cattle as circumstances allow. This is aggravated by a communal grazing system, which creates a divergence between the social and private evaluations of grazing (see Ch.4). In such an environment, livestock diseases control may, for example, be self-defeating as it may lead to explosion of cattle numbers, with consequent overgrazing and denudation of grazing land, instead of leading to a higher take-off for the market. In certain circumstances however, disease control may lead to a lower stocking density if farmers were induced to keep large herds relative to the carrying capacity of land to hedge against risk. By reducing the risk, disease control may therefore result in lower herd sizes and optimal management of grazing land.

Livestock development, like most other agricultural development programmes, is characterized by investment indivisibilities . It is less responsive to piecemeal efforts, but instead requires a package approach and simultaneous investments in a wide-range of self-supporting and complementary services in improved breeding, feeding and nutrition, land tenure system, marketing and pricing policies, and so on. Therefore, though dealing with partial analysis of the ticks and tick-borne disease problem, this paper would not be complete without mentioning these other aspects of livestock sector development. In the following two sections, we briefly analyse the economic impact of the other livestock diseases that confront the livestock sector, and review shortcomings of the present marketing and pricing policies in the sector. The other factors will be mentioned in subsequent analysis and are well documented in several studies in the bibliography. Section 2.4 considers tick control in Kenya on a historical perspective.

2.2: Animal Diseases in the Livestock Sector

Animal diseases are a major constraint to the development of the livestock sector in Kenya. Apart from tick-borne diseases, other diseases are prevalent. The most important of these are epidemic in nature and include the Foot and Mouth Disease (FMD), Contagious Bovine Pleuro-pneumonia (CBPP) and rinderpest. However these diseases are well under control in the central belt of the country comprising the high potential areas where high yielding livestock are kept. They are therefore confined to the rangeland. The control policy is to create a buffer disease-free zone around the high potential areas.

The diseases impose both direct and indirect losses. For FMD, the disease causes loss of milk output, abortions and general loss of condition of the animals afflicted. With all the diseases, loss from mortality is low. Rather, it is the indirect losses that are more significant, resulting mainly from market restrictions and quarantines. These delay sale of slaughter stock and may lower the eventual receipts through weight loss in quarantine, and if animals are carried forward to the dry season. In the case of CBPP, quarantine may exceed three months.

Unlike ECF, vaccination is possible against FMD, CBPP and rinderpest. The vaccine for the FMD was developed as early as 1954. In 1970, an FMD laboratory was set up by the government with the assistance of the Wellcome Research Organisation, at Embakasi. The laboratory has facilities, among other functions, for vaccine production (Mureithi, p.179). However, the animals require revaccination after every six months or one year, making the cost of continuity high (IDS/OP12, p.9-42). This is further complicated by the existence of several strains of the diseases (the most prevalent being SAT2, "O", "C", and "A" strains) necessitating different vaccine types. In 1971, about 2.3 million vaccinations were undertaken in the FMD campaign areas. With assistance from the Swedish Government in the livestock diseases control programme, the number of vaccinations rose to about 4.5 million in the 1975/76 period. At the same time, 731,000 vaccinations were undertaken against CBPP. Vaccination against the three diseases is undertaken together. According to the SIDA Mission (1978), however, vaccination against rinderpest and CBPP is just routine, there being no outbreaks from the diseases in the last eight and five years respectively. On the other hand, and according to Mureithi[2], control of FMD is ranked as the most challenging job facing the department of Veterinary Services, requiring mass vaccination campaigns. ECF takes the second place. While it probably causes larger financial losses to the economy and to farmers, it is in principle easier to control: all it requires is the cooperation of the farmers in spraying and dipping their livestock.

Trypanosomiasis, which is transmitted by the tsetse fly, is confined to isolated localities, particularly in the Coast and Nyanza provinces and along river banks. Consequently, unlike Uganda and Tanzania, Kenya has not undertaken large-scale control programmes. The control policy in these areas rely on chemotherapy and prophylaxis[3]. Other diseases of economic importances include the Rift Valley Fever, anthrax and the reproduction diseases such as Brucellosis, Vibriosis, Trichomomiasis, etc.

2.3 The Marketing and Pricing Policies in the Livestock Sector[4]

The formal marketing of milk and beef in Kenya is handled by monopolistic agencies. Milk is handled by the Kenya Cooperative Creameries (KCC), while beef is handled by a parastatal, the Kenya Meat Commission (KMC). According to one estimate, KCC handles 25% of all milk production and 96% of all milk passing through known commercial channels (Ruigu *et al.*, p.6). KMC faces more competition, however, both from legal and illegal slaughter houses. It therefore handles a relatively smaller proportion of total beef output. This is indicated by the following estimates of percentage proportion of cattle and milk in smallholder areas handled by the different marketing channels:

	Cooperative Society	Marketing Board	Trader	Consumer	Other
Cattle	6	-	73	10	11
Milk	63	9	11	16	1

Source: Economic Survey, 1978, p.100.

From the table, it is evident that a significant proportion of meat and milk is handled through informal marketing channels. In the case of milk, the available evidence indicates that farmers first satisfy the local demand for milk, and sell to the formal channel when the local demand is saturated and the price falls to the KCC price level. In effect, the KCC provides a floor price and acts as a buyer of last resort. The impact of this is to aggravate the seasonal fluctuations of the milk delivered to the KCC. A similar mechanism probably applies in the beef market.

Both the KMC and KCC mainly cater to the urban consumers, with 70% of total milk sales going to Nairobi and Mombasa. The prices in the formal marketing channels are strictly controlled.

The two marketing agencies are virtual monopolies in the exportation of milk and meat and their products. In the past, however, substantial exports were made to partners in the former East African Community, particularly Uganda. In both commodities Kenya is not very competitive in the world markets. Only 10% of the total beef output and 50% of the KMC output is exported.

There is however a high potential for increased exports, especially to the Middle East and other countries in Africa, if Kenya can produce a substantial export surplus or if it could curtail domestic consumption to support such a programme.

Milk and beef are semi-luxuries at a low level of income in the agricultural and urban areas. As such, the income elasticity of demand is high. However, the demand elasticity is likely to decline at higher levels of income. Demand for milk and meat and their products is expected to increase with population growth and urbanisation.

There is a general consensus in the literature that the pricing policies in the livestock sector are not conducive to increased output and productivity in the sector. This is elaborated below.

Milk Pricing Policy

Since 1971, the KCC producer price of milk has been set by Presidential decrees. A uniform price is paid to the farmers irrespective of the season and location in relation to consuming areas. These aggravate seasonality of milk supply to consumers, mainly in urban areas. Ideally, the value of a marginal unit of milk to a producer should incorporate transportation costs to the consumers. Since it is cheaper to transport milk products such as cream, butter, cheese etc, then the policy implication of this is a judicious allocation of processing plants, so that those serving areas near the consuming areas specialise in processing the liquid milk for distribution, while the other areas should undertake the processing of milk products(i.e., the farm gate price (social value) should vary with the transport costs which are a function of distance).

A uniform price policy also aggravates the seasonal fluctuations in the milk delivered to the KCC. Such a price structure ignores the economic fact that it is cheaper to produce milk in the wet season than in the dry. In the wet season, grazing is generally plentiful and nutritious. In the dry season, the farmers often have to supplement grazing with stored or purchased feeds. The farmers therefore will tend to calve their cows seasonally. As a Ministry of Agriculture manual for junior agricultural officers advises:

> The season in which cows should calve down depends on the milk marketing arrangements in force. If there is a standard price for milk throughout the year, then it will benefit the farmer to produce as much as possible of his milk in the wet season to make the best use of pastures with the result that he has to buy less of concentrates. On the other hand, if a premium is paid for dry weather milk, then it may be advantageous to have at least some cows calving down so that they are in full production in the [dry season][5].

The pattern of large fluctuations of milk deliveries to the KCC imposes costs in several ways. In the dry season, much of the processing equipment is left idle, so that large fixed costs are incurred. In the wet season, milk is processed to products which have only a low realised value per litre of whole milk taken in so that it is in the wet season that KCC is least viable. One policy implication is the introduction of a price bonus to the milk delivered in the dry season. The bonus should depend on the proportion of milk sold as fluid milk to consumers, i.e. the highest realised price. Such a price structure would go a long way in stabilising milk deliveries to the KCC, and improve its operating efficiency. The consumer price could vary to encourage consumption during the flush season, although this is not essential for the operation of the envisaged price structure.

Beef Pricing Policy

There is a wide consensus that the price structure for beef is not conducive to development of the subsector.[6] The official policy in the past has been to keep the prices of beef paid by the middle and low income groups low. The surplus resulting over the domestic consumption is then exported. The low consumer prices tend to squeeze the margins that the farmers receive. While the producer and retail prices of beef have increased only slowly in the past, operating expenses in feed, dip fluids, etc, have risen subtantially. According to Heyer *et al.* (p.330)

> Higher producer prices that would follow from a more rational pricing would provide welcome additional incentives to produce beef. Higher domestic consumer prices would discourage beef consumption, encourage the use of alternatives like poultry, pork and mutton, and it would free more beef for the export market. At present . . . the consumers gaining most are in the higher income groups.

The other problems in the pricing of beef relates to generally low operative efficiency and low capacity utilisation of the KMC, and inadequate incentives to stratify Kenya's beef industry - introducing geographical, structural, trade and transport relations.

2.4: Tick Control in Kenya: A Historical Perspective

The first case of ECF was diagnosed in Kenya in 1904, and the disease was subsequently found to be endemic in several regions of the country. Tick control was instituted in 1912 and became compulsory in most areas of the former scheduled (European) areas (Walker,p.21).

During the colonial period, reviews of the extent and efficiency of tick control distinguished the former scheduled and non-scheduled (African) areas. In the former,standards of tick control were higher, and were well supported by quarantines and the cattle cleansing ordinances, so that by the mid-1950s, ECF was reported as no longer a major problem in most of these areas. The exception was where squatters were reportedly permitted to keep livestock (mainly the indigenous Zebu) that losses from tick-borne diseases were high. In the African areas, tick-borne diseases were more prevalent. However, the value of tick-control was widely acknowledged, particularly in the Central Province and parts of the Rift Valley Province, such as the Nandi and Kipsigis Reserve areas. These were the areas where land consolidation had progressed and farmers had acquired improved cattle - mainly from the European Settlement areas.

Kenya inherited an unenviable tick control situation upon attainment of political independence in 1963. In the African areas where standards of tick control were formerly high, drought conditions in the early 1960s forced farmers to graze in the communal areas such as forest land. The consequence was an upsurge in mortality from tick-borne diseases. Heavy and prolonged rains which subsequently occurred interfered with private spraying and dipping. In other areas, use of communal facilities was hindered by lack of dipping fees, these being famine years. The takeover of European farms and the settlement of a large number of African farmers in the former scheduled areas further aggravated the situation - mainly as a result of inexperience of the new farmers and mismanagement of communal control facilities. The result was widespread use of understrength acaricides. For example, the 1964 Veterinary department annual report reveals that 30% of the samples analysed from Transzoia District was understrength, while a test made on settlement schemes in the Machakos district recorded 80% below strength. This was accentuated by extensive mobility of cattle and trespassing.

A major national problem has been the management of acaricides used so as to avert the development of resistance in the major ticks in the country. Since 1946, the government has had to approve the acaricides used in designated cattle cleansing areas. In 1968, this was extended to cover the whole country. An approved acaricide has to fulfil certain conditions relating to its biological efficiency, residual effects, exhaustion rate, pollution of animal products and its cost efficiency (Kane, p.72).

Basically 3 types of effective acaricides have been used in the recent past: the chlorinated hydrocarbons (mainly toxaphene), the organophosphates (OP) and mixtures of the two. In 1913-49, only arsenic was used as an acaricide. Toxaphene was introduced in 1950, and the one-host Blue Tick, Boophilus decoloratus soon developed resistance to it. The other types of acaricides were introduced in 1961-62, but usage of taxaphene continued in most pasts of the country, against the most important tick, R. appendiculatus. The FAO/UNDP Survey undertaken in the early 1970s found 50% of all cattle in the sample, and those under tick-control using toxaphene one way or another. Resistance in the R. app. to taxaphene was only noted in 1971. Due to the general development of tick resistance to toxaphene, use of the OP compounds and its mixtures has progressed rapidly, enhanced by their cost efficiency and residual effect on treated animals. A related problem is that of pollution. Residuals of toxaphene have been found in beef and dairy products, though below the generally accepted critical levels. Due to this problem and that of tick-resistance, the Veterinary Dept. in 1976 banned the further usage on cattle of arsenic, toxaphene/OP mixtures, and a group of other OP compounds (Kane, p.74).

Tick control facilities, particularly the cattle dips in the post-independence period have been built mainly through self-help - a reflection of farmer awareness of benefits of tick control. Farmers have, at times, been assisted by external agencies such as the Danish Dip Project (started in 1969 to assist self-help groups in the construction of dips all over the country, and has been contributing about half the total capital expenses in dip construction.),the European Economic Community (particularly in the Coast and Eastern Provinces) and DANIDA (e.g. Kericho).

A major problem has been the mismanagement of the communal cattle dips on the smallholder and pastoral areas. As the 1966 annual report of the Veterinary Department states:

> the enthuasism shown for the provision of communal dips is not matched by the same willingness or ability to operate them satisfactorily and sporadic dipping and understrength dipping fluid allow them [diseases] to continue.

This has been accentuated by the steady increase in the population of improved cattle susceptible to tick-borne diseases, so that mortality losses have tended to increase rather than fall. In these areas, a vicious cycle has been noted. Poorly managed and understrength dips dampen the farmers incentive to use the available cattle dips - and when the farmers discover that the dipping fluid is not effective, they stop dipping. This leads to inadequacy of cash to purchase the acaricide and pay the dip attendant. The vicious cycle is usually initiated by misuse of fees collected. Ultimately, the dip is closed, at times for an extended time period. This is despite the continued need for them to abate ticks and tick-borne diseases. In the large-scale farm areas, fewer problems are experienced as farmers own the control facilities privately.

Mainly as a result of the cattle dip mismanagement problems, and to avert rapid development in tick resistance to acaricides in usage, a Tick Control Project was initiated in 1976. It was incorporated in the Integrated Agricultural Development Programme (I.A.D.P.). The aim of the project is to eventually take-over the purchase and distribution of acaricides to and supervision of the operation of cattle dips throughout the smallscale farming areas and pastoral areas where the incidence of tick-borne diseases is high and where there are enough cattle dips. The first group of dips were taken over in 1977 in several smallholder districts in the country under Phase I of the project. The districts covered in this phase included Bungoma, Kakamega, Kisii, Muranga, Nyeri, Kirinyaga, Embu, Meru, Kiambu, Nyandarua and Nandi, and holding about 1800 dips and spray races (functioning and non-functioning) of the estimated 5500 in the whole country.[7]

Footnotes

1. For the different explanations, see for example Peberdy (Ch.1). Heyer et al.,(p.104), Ferguson (Ch.1), and the FAO 1967 Livestock Survey (1967).

2. Mureithi, I.E. Role of Veterinary Services in the Development of Kenya's Livestock Industry. Kenya Farmer. Nairobi, Feb. 1976.

3. See Jahnke, H.E. Tsetse flies and livestock Development in East Africa, A study in Environmental Economics, Africa-Studies 87, Info-Institut fur Wirtschaftsforschung Munchen, 1976.

4. This section draws heavily from the works of Hopcraft and Ruigu on the different aspects of Kenya's dairy industry. They are cited in the bibliography. The analysis on the beef industry also draws heavily from several sources, among which are Heyer et al.,(1976), and Peberdy (1970).

5. Ministry of Agriculture. Crop and Livestock Manual 1971/2. Animal Advisory Leaflet No. 277. p.1.

6. See for example Heyer et al.,(1976), Peberdy (1970) and Aldington (1968).

7. Ministry of Agriculture Tick Control Project file.

CHAPTER THREE

ECONOMIC POLICY IN THE CONTROL OF TICKS AND TICK-BORNE DISEASES, PARTICULARLY IN RELATION TO ECF.

3.1: Introduction

In Chapter One, it was indicated that several economic factors operate in a tick and tick-borne diseases environment to cause a divergence between the optimal level of individual farmer control and the social level. This was used as an argument for some level of government involvement. This chapter examines these factors in more detail.

One can delineate two extreme options in tick control policy. First, the government may place the onus for the construction and maintenance of tick control facilities on the livestock farmers, individually and severally. In such a situation, tick control by individual farmers should be largely voluntary. The state may, alternatively, undertake the responsibility for the provision and efficient maintenance of tick control facilities, and supervise the activities of the farmers in tick control. It is then imperative to select the option that leads to optimal allocation of economic resources.

Such an analysis is opportune in Kenya at the present. The past few years has witnessed a de facto shift in government policy from passiveness to a more active role in national tick control activities. This, no doubt, has been prompted by disillusionment with farmers' private control efforts, resulting mainly from poor management of cattle dips in the country. In 1977, for instance and as was said in the last chapter, the state, utilising mainly external financial assistance, took over the running of dips and spray races in a number of smallholder districts in Central, Western, Nyanza and Eastern Provinces in Kenya. This process is expected to culminate in the taking over of all such tick-control facilities in the country by the end of 1983. In the meantime the government intends to supervise strictly dipping programmes in various parts of the country (1979/83 Devt. Plan, p. 244) . The expanded involvement of the state in tick control activities in the last few years is reflected in the following data on budget allocation to tick control .

Table 3:1: Approved and Estimated Government Budget Allocation to the Maintenance and Construction of Dips in Kenya. K£'000

	Approved Previous Year	Estimated For the Year
1977/78		
Maintenance of dips	-	30
Construction of dips	-	-
1978/79		
Maintenance	64,750	239,500
Construction	-	80,000
1979/80		
Maintenance	239,500	285,000
Construction	80,000	69,200

Source: Government Expenditure Estimates : Various Issues.

Section two presents the economic model that is utilised in subsequent analysis. Section three analyses the economic factors that cause a relatively laissez faire approach to tick control to fail to allocate resources social optimally. Section four suggests some remedies to the 'market failure', and the form state interference may take.

3.2: An Economic Framework for use in Analysing Tick Control.

In principle, rational farmers should allocate resources to tick control in conformity to the private benefits they expect therefrom. This should hold at the community and individual levels. At the community level, the expected benefits of control are the alleviated production losses from ticks and tick-borne diseases. The costs include the expenses of building and maintaining tick control facilities, and the efforts of mustering the animals for control.

The marginal benefits from tick control are expected to decline as the level of control is raised. Research done in Kenya and elsewhere show that, in disease endemic areas, there is a positive correlation between the average number of ticks and the severity and incidence of tick-borne diseases. The FAO/UNDP Survey found a similar relationship in Kenya - between the number of cattle responding positively to the Theileria Parva IHA serological test and the average number of ticks on "undipped" cattle in the survey districts.

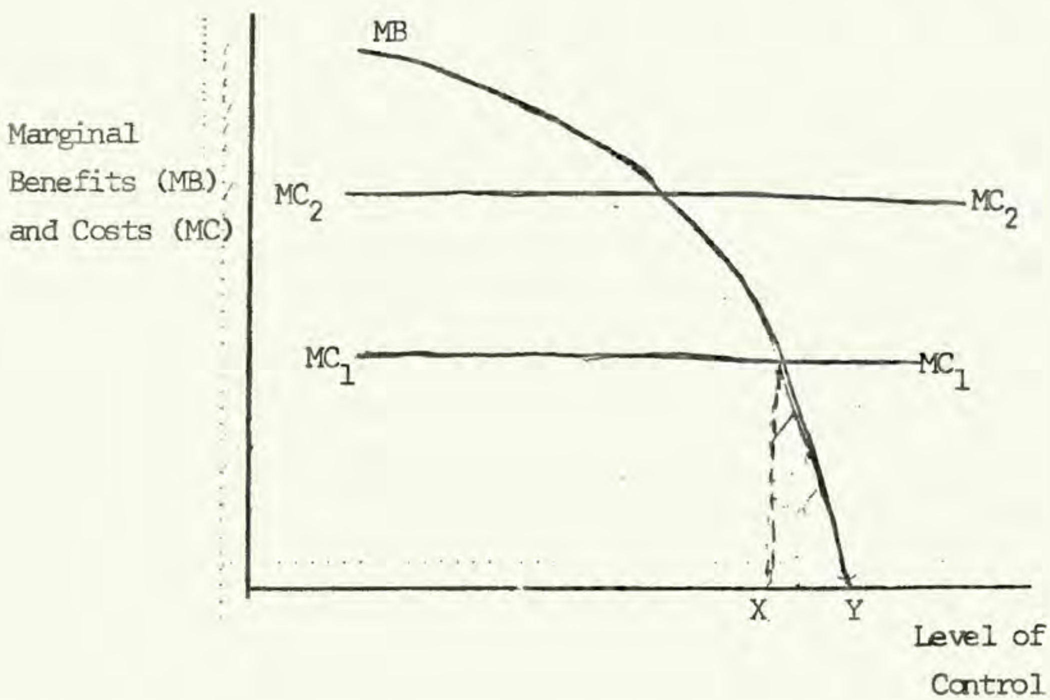
No. of ticks	% of cattle responding positively to IHA test
0	16.1
1-5	39.3
6-25	54.0
26-50	55.1
51-80	64.6
81-100	71.4
More than 100	74.2

Source: FAO/UNDP (d), p.6

Yoeman (1968) in Tanzania found a similar "quantitative relationship between the average rates of infestation and the way in which ECF manifests itself in different zones". Some authors have found the relationship extending to single indigenous animals in an ECF endemic area. A study by Barnett (1957, p.351), dealing specifically with Zebu calves, concluded that it is "fairly certain that there . . . [is] a direct [positive] mathematic relationship between the infecting dose and the recovery rate". However, for the susceptible indigenous and/the exotic cattle, one infected tick is fatal to the animal.

Due to size economies and indivisibility of tick control facilities, most farmers rely on communal dips. As such, the marginal cost to a single farmer in the form of dipping fees and mustering costs may be taken to be fairly constant. Similar reasoning may be applied to marginal costs of control at the community level. They are likely to be fairly constant, consisting of the construction of an 'extra' dip, or spray race.

The relationships are depicted in the following diagram:



The marginal benefit curve is drawn to indicate an increasing rate of decline of the marginal benefits. Also, a certain critical level of control is required if it is to be effective, taking either the rate of control or dosage of acaricides use X is the "economic threshold" - that level of control at which the incremental costs of damage are equal to the incremental returns gained from damage reduction[1]. A crucial point to note is that the optimal level of control permit some losses to occur from ticks and tick-borne diseases. The size of the losses is denoted by the shaded area. There is another reason for allowing some tick population to persist : to propagate immunity of the indigenous livestock. This lowers the marginal benefits from eradicating the tick population.

The model has several implications for the farmers' tick-control efforts. The level of control will vary from area to area, depending on the marginal benefits from control, both actual and perceived. Assuming good information on the seasonal abundance and activity of ticks, it should also vary with the seasons. Enthuasism for regular dipping tends to decline as the number of ticks on cattle decline over time. On the cost side, the level of control tends to decline when farmers are short of cash, and when it conflicts with other agricultural activities. Dipping fees exert a major influence on farmer control behaviour in an area over time. In Bungoma, for example, an extreme case is reported where the dip management committee experimented with a system of fee dipping, but compensated indirectly through a higher rate of cash collected through the county council. The experiment was halted when the dip management was taken over by the government, and farmers were instead required to pay cash upon dipping. The proportion of cattle presented for dipping fell from 90% to 0.4% and it reportedly took the officials a long time to persuade the farmers to dip again[2].

According to the model, the level of control would be improved through more efficient pricing and marketing policies of the livestock products, and encouraged improvement of cattle,

- through both a higher productivity and susceptibility to diseases. Development of cheaper, and less cumbersome methods of control would have a similar impact.

In the tradition of the welfare economics,the state should only interfere if such a relatively decentralised, laissez faire system fails to allocate resources Pareto optimally, and if the transanction costs of making the system work do not outweigh the benefits realised (Noorgard p.57) . Several factors operate in a tick and tick-borne disease environment to cause "market failure", thus leading to a significant divergenece between the optimal decisions of a single farmer, and those of the community as a whole, and resulting in misallocation of resources, and a lower level of social welfare. These factors are discussed below.

3.3: Factors leading to 'failure' of a Laissez Faire System of Tick and Tick-borne Disease Control.

As mentioned in Ch.One,the factors that we consider important are - :

(1) Externalities in tick control

(2) Risk and uncertainty in a tick and tick-borne diseases enviornment

(3) Farmer ignorance

and (4) Economies of scale and indivisibilities of tick control activities and facilities.

1. Externalities

Externalities are costs or benefits that a single economic agent imposes or bestows on another without compensation or payment. They are, therefore, not included in the private decision making calculus. They arise from direct interactions and inter-dependence of behaviour. By failing to be included in private decisions, they lead to a divergence between the private and social cost-benefit calculations (Bator, p.359).

Several types of externalities will operate in tick-control. They evolve from interseasonal dynamics, effect of control on neighbouring farmers, chemical pollution of the environment and animal products, tick-resistance to acaricides etc (Regev et al., 1974). This paper analyses only the first two. Acting individually, farmers will equate their incremental costs of control with incremental returns. But, each farmer by failing to consider the benefits or costs arising from his control efforts spreading to other farmers, and accruing in the future, will undertake an overall level of control that is unlikely to be socially optimal.

Spread Externalities in Tick Control

This group of externalities is the most important, and falls mainly in the category that Bator calls "ownership externalities". They arise from non appropriation of benefits provided in tick control or compensation for the costs imposed from the spread of ticks and diseases, in the absence of tick control. Since ticks are fairly mobile over space - on cattle, small domestic animals, buffaloes and even by wind, a farmer, by controlling ticks on his livestock bestows benefits on his neighbours in that there is reduced risk of ticks and disease spreading to their livestock. On the other hand, by failing to undertake tick control, the farmer not only endangers his livestock, (a cost he has weighed against the expenses of control), but also those of his neighbours. Whether he imposes a positive or negative externality depends on the other farmers' relative level of control. Even when the levels of control are symmetrical and of the same standard, misallocation of resources occur- as farmers only include private benefits and costs in their decisions, this leading to a lower societal level of control below the maximum return possible from the resources used (Noorgard, p. 58).

In Kenya, spread externalities are most pronounced in areas where both improved and indigenous cattle are kept together, or in close proximity to one another. Indigenous cattle are not only less productive, but have developed immunity to the major tick-borne diseases. Therefore, most of the benefits from undertaking tick control accrue externally, mainly to the farmers who maintain the more productive but tick-borne diseases susceptible improved cattle. By failing to include such benefits in their private cost-benefit calculations, they are, therefore, likely to undertake only a low level of control.

This imposes negative externalities on the other farmers, through spread of ticks and diseases.

For several reasons, the farmer does not 'internalise' the externality by appropriating the external benefits that he provides free to his neighbours when he undertakes a relatively higher level of control. The reasons include, first, the absence of technical and legal bases from which to compute and seek payment for such benefits. It would be very difficult to attach monetary values to them, while the cost of the exercise may not be economically justified. Moreover, the recipients are not likely to pay; the benefits are unsolicitated and reciprocally provided when farmers undertake similar levels of control. Secondly, the benefits (or costs) are of the nature of a public good, with the associated "free-rider" rationality. The externalities accrue to more than one farmer, with one person's 'consumption' not generally reducing the amounts available to others (nonrivalness in consumption), while it is not economically viable to exclude some neighbours from getting the externalities. (Johnston, p. 8).

Stock Externalities in Tick Control

For most farm communities, each farmer's control efforts have only a small impact on the total tick population in the area. Due to the mobility of ticks, individual farmers will not incorporate the temporal component in their tick control policy in any one period. But the tick population dynamics depend on the areas' surviving stock in the present control period. From an interseasonal point of view, then, an individual farmer imposes externalities, which take the form of a higher incidence of diseases and other losses in the future. This is well summarised by Regev <u>et</u> <u>al</u>. (1976, p.195).

> In the longrun, each individual farmer is affected by the cumulative effects of individual decisions. In this case, the pest constitutes a "common property resource" and a non-regulated market would not yield the optimal solution.

One way the society may remedy the problem is through applying capital budgeting principles in tick control, so that, instead of comparing costs and benefits of control in any one period as with individual farmers, they optimise the discounted net returns to tick control (Headley, p.281). . An alternative remedy would be to induce farmers to undertake a higher level of control through extension. The objective of extension would be to enhance the mutual cooperation of the farmers, so that they relate the current to future costs and benefits of tick control.

2. <u>Risk and Uncertainty</u>

Technically, the term "risk" is used to refer to a situation where the outcomes are uncertain, but where one can place probabilistic values on the possible outcomes. In an "uncertain" situation, such probabilistic values cannot be applied. However, the terms are generally used interchangeably.

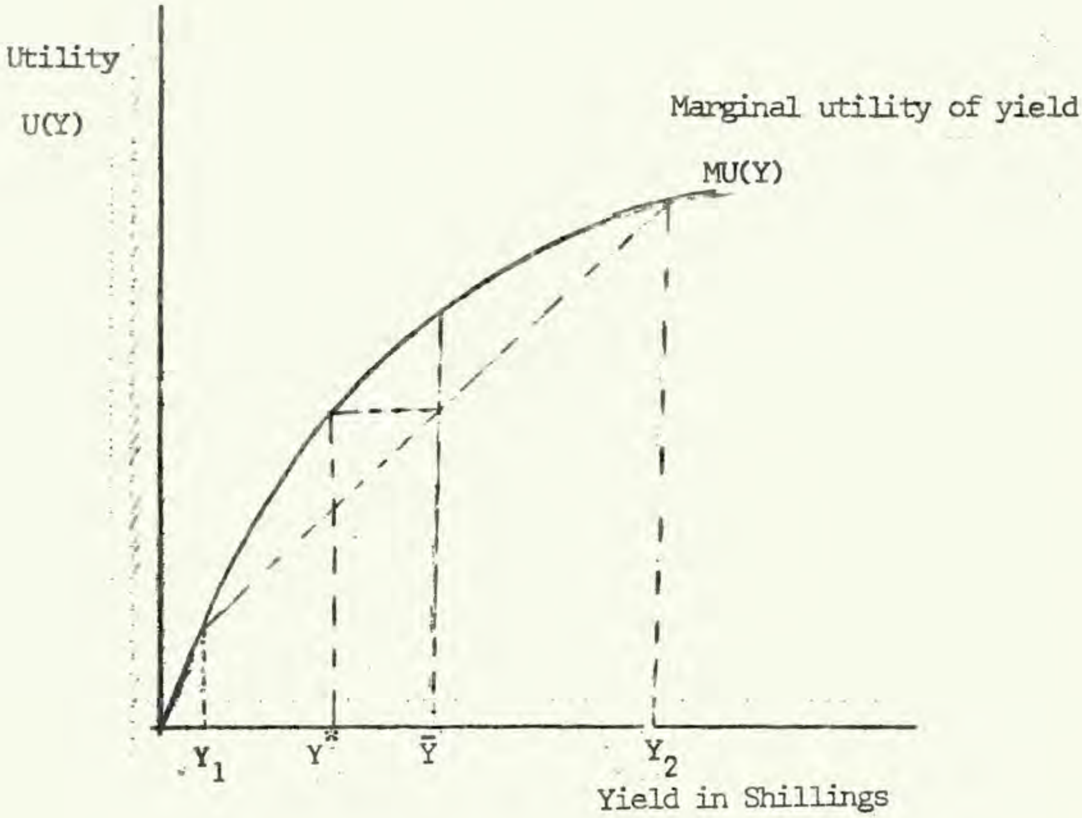
Risk and uncertainty will manifest themselves in several ways in influencing the allocation of resources in a tick and tick-borne diseases environment and in control. Only two are discussed below: the influence on cattle breed portfolio that is kept by a community of farmers, and on the level of control that the farmers adopt.

Impact on the Improvement of Livestock

Improvement of cattle in a tick and tick-borne diseases environment provides a classic case of trade-off between risk and yield. In such an environment, increase in productivity from the improvement is achieved at the expense of a higher degree of susceptibility to tick-borne diseases. Therefore, given the unpredictability of diseases in general, improvement of cattle is accompained by a higher and more costly risk of mortality.

There is general consensus in the economic theory literature that individuals act to maximize expected utility of income instead of the expected monetary value of an uncertain and risky investment opportunity. Most individuals also tend to display risk aversion, so that they prefer a certain event to a risky one, though of equal expected value. Therefore, the utility they get from an investment yield increases, but at a decreasing rate.

The predicted behaviour of risk averse farmers is illustrated below, where an investment in improved cattle has two outcomes, say, survival and death.



Y_1 denotes the expected yield of an improved animal when it contracts a tick-borne disease early in life and dies. Y_2 denotes the situation when the full productive life of the animal is achieved. A risk-neutral farmer considers the expected value of yields Y_1 and Y_2, $\bar{Y}$. When he is risk averse, the investment is only worth Y^*. ($\bar{Y}$-Y^*) represents what the farmer would be willing to pay to convert the risky expectation to a certain one. The higher the concavity and degree of risk aversion, the higher is the size of this premium.

In this way, risk and uncertainty reduce the incentive for farmers to improve their livestock. This reduces the level of welfare below that obtainable from existing resources and technology, in the sense of a failure to reach a Pareto optimal state (Arrow, p.184).

Several economists, such as Arrow (1958) and Pratt (1964), have attempted to develop measures of risk aversion. The measures show that the willingness of an individual farmer to undertake a risky investment depends on the relative probabilities of the various outcomes, the wealth status of the individual farmer and the size of the investment. Therefore, the farmers response to risk hinge on the three major components of risk aversion.

The degree of risk of mortality from ECF and other tick-borne diseases in different ecological zones probably explains the results of a study undertaken by McCullock (1968) in Sukumaland, Tanzania. He found cattle holdings in the clean areas to be significantly larger than those in the ECF enzootic areas. They were also larger in the enzootic areas than in the ECF - epizootic areas. Farmers, perhaps, adjusted their farming portfolios in enzootic and epizootic zones from livestock to other agricultural activities. In several areas in Africa, farmers respond to risk and uncertainty of mortality from livestock diseases by keeping large numbers of indigenous cattle. This results in overgrazing and reduced carrying capacity of land (Lele, p. 56).

The impact of risk on the livestock farmers decisions is also likely to be influenced by the method of cattle improvement adopted. If artificial insemination (AI) is used, it is the calves that mainly die. The size of the investment is thus small, and so is the degree of risk aversion. This method constrasts to where adult exotic cattle are purchased and distributed to the farmers. Risk-aversion is higher. The AI method also allows the farmers to gain experience in cattle management, and thereby reduces the probability of loss (Hopcraft, p.70).

Due to the wealth status aspect, the rich and progressive farmers will be less risk averse, and will undertake a higher level of improvement, but at the expense of equity.

Level of Control

Risk and uncertainty have an independent influence on the degree of tick control undertaken by farmers, besides the influence through the degree of improvement of livestock in high and medium potential areas of the country. Earlier on, it was indicated that the severity of tick-borne disease varies positively with the infection dose, and so with the number of infected ticks feeding on the partially immune animals. But the number of infected ticks in an area is a highly uncertain event. Only a small proportion of ticks in an ECF endemic area carry the protozoa, T. Parva. The proportion will depend on such uncertain (though not mutually exclusive) events as the proportion of tick resistance to acaricides, the total number of ticks in an area and the effectiveness of control measures.

Taking most farmers to be risk averse, then uncertainty of the rate of infection, the size of the infesting tick population, and effectiveness of control measures will induce a higher level of control (Feder,p87; Noorgard, p.49). The farmers will devote too many resources to tick control relative to the Pareto optimal level, thereby reducing the risk at the margin. This acts as a form of "insurance" against the risks involved. However, the overallocation of resources to tick control may be in the form of adoption of more diversified and reliable agricultural enterprises. Those who maintain improved livestock will most likely undertake more dipping and spraying than what is socially optimal.

3. Farmer Ignorance

Farmers will make nonoptimal decisions if they have imperfect and inadequate information on the expected benefits and costs of control. They may also fail to make optimal decisions due to the complexity of cattle management problems that they face, and lack of supporting services needed for improved animal husbandry. Ignorance will also raise risk and uncertainty in a tick and tick-borne disease environment.

Due to the bias of the traditional cattle-keeping institutions towards the status quo, the farmers will tend to underinvest in tick-control. This is aggravated by the fact that the physical damages caused by ticks are not easily detectable in the shortrun. The same may apply to tick-borne diseases, when farmers do not understand the underlying causes of mortality. As Hopcraft (1976, p.60) points out, some farmers do not know why they are asked to dip concientiously in some areas of Kenya :

> - - - - where tick-borne disease is endemic, the reason for cattle deaths is frequently not understood by farmers and grade cattle are thought to have "bad blood" or to be unsuitable for Kenya, even though in every other respect the dairy potential of the area may be extremely high.

In such situations the level of control will be socially subboptimal, and state intervention is desirable. This should take the form of extension and farmer education on the benefits and costs of alternative control strategies (Johnston,p.9) . Mathew (1972) argues that there is an economic case for general state subsidisation of tick control if the benefits /are greater than what the farmers, due to ignorance, apparently realize. Otherwise they will undertake less control than what the society considers to be in their best interest .

4. Scale Economies in Tick Control Activities and Facilities

Most tick control activities and facilities /are characterized by economies of scale and indivisibilities. This is true of several tick control facilities, such as the cattle dips and spray races, and research. In the absense of 'divisibilities' in tick-control activities, the laissez faire system breaks down, as it depends on marginal adjustments. As such private provision of the facilities and research would be sub-optimal.

The four major factors analysed above cause the private incentives system to motivate less than socially acceptable allocation of resources in a tick and tick-borne disease environment. This underallocation is used as an argument for state intervention.

This argument is supported by the impact of ticks and tick-borne diseases on the distribution of income. Due to the unpredictable nature of the diseases, and the size of the losses involved, some group of farmers in a community may be affected more than others. The resulting impact may be deemed inequitable and undesired. The less risk averse and more enterprising farmers are also likely to genetically improve their livestock relative to others. Assuming improved cattle have higher returns compared to other agricultural enterprises in high and medium potential areas, then this is a major source of interpersonal and regional inequality. State intervention in tick control would reduce the impact of these sources of income inequalities.

3.4: Some Remedies to Externalities and Risk in Tick Control.

Various solutions are suggested in the economic literature to deal with the various causes of "market failure". In this section, those suggestions relevant to tick control are examined. Of the factors considered above, only spread externalities and risk are included. Methods of handling the other causes of failure of private tick control to reach socially optimal levels were mentioned in the course of analysis in the previous section.

Spread Externalities

Several remedies for externalities which are suggested in the economic literature are not much relevant to the problem at hand. An example of this is the classical corrective measure called the "Pigovian" solution. This was suggested by Pigou in the 1930s, and consists of the application of a set of taxes and subsidies that internalise the externalities. This remedy is not practical, particularly if it is to be applied in a rural economy.

Coase (1960) suggests that where a small number of persons is involved, as is the case with the large-holder agricultural areas, the individuals can settle the problem among themselves. There is no reason therefore for judicial and administrative interference. The afflicted persons, say the farmers who keep improved cattle, have reason, according to the Coase, to "bribe" the farmers who keep the unimproved cattle to raise their level of control. The role of the state is merely to define and specify the property rights that conform with efficient allocation of resources and equity. According to Coase, and assuming low transaction costs, rational farmers will seek each other and conclude agreements that lead to Pareto efficiency.

Such a relatively laissez faire approach is not very relevant in smallholder livestock keeping areas. Perhaps a more useful approach is the one suggested by Baumol (1972):

> setting standards, more or less arbitrarily ... that are considered to be tolerable, and the design of charges whose rates are shown by experience to be sufficient to achieve the pre-selected standards of efficiency.

In principle this is the approach followed in Kenya. Under the Cattle Cleansing Ordinance (Kenya Laws, cap. 359) farmers are mandatorily required to adopt a certain rate of dipping (mostly the bio-technically efficient rate), failing which they are prosecuted and fined. The problem with this method is that it entails heavy administrative and regulatory costs, and is not flexible to changed conditions, for example, decreased tick and diseases challenge. As such, it is essential that the state apply the principle of maximum returns, so that the cost of intervention is related to the alleviated production losses in the livestock sector in each particular area and period.

From the nature of spread externalities, one can draw some inferences for the financing of the state intervention. As indicated earlier on, spread externalities have major characteristics of a public good, but slightly inclining towards merit goods. Allocative efficiency is, therefore, attained only when a zero or nominal direct change is made for the "consumption" of such externalities. As such, where the benefits of control are largely external as with the partially immune indigenous cattle, little or no direct changes should be imposed for tick control. This is supported by experience from E.E.C. - supported tick-control projects which do not impose dipping fees. In Machakos and Taita Taveta Districts, a MOA working paper[3] notes that:

"(1) dipping rates increased dramatically e.g. in Taveta from about 20% to 60-70%.

(2) Tick-Borne disease control becomes efficient e.g. only one case of ECF was reported compared to roughly 100 incidences in the pre-project phase, and

(3) farmers become more receptive for new innovations like upgrading, growing of fodder crops etc."

Similarly, overall tick control is a public good, with the marginal cost of providing tick control to an additional livestock farmer in an area being nominal. On the other hand, it is socially very costly to exclude those who do not pay for tick control. There is therefore an economic case for collective provision and subsidisation of tick control resources through general taxation and/or lumpsum taxes on the livestock sector which have no resource allocative impact. For instance, dipping fees could partially be recovered through a levy on livestock products like milk, meat, hides, and skins.

Risk and Uncertainty

One way the farmers may handle risk in a tick and tick-borne diseases environment is to transfer it to other economic units who are willing and/or able to bear the risks through their wealth or ability to pool risks over numerous and diverse activities, or claimants (Noorgard, 1976). The state may intervene by encouraging the development of such private markets for risk, or may undertake the function itself[4]. The state may also ameliorate the effects of uncertainty by dissemination of information. This would permit the farmers to make informed prediction of the future states of nature.

However, provision of markets for risk bearing against animal diseases would face formidable problems, and few commercial firms would undertake the function. A major inherent problem is that of the moral hazard, arising from the impact of insurance on the incentives. According to Arrow (1958, p. 202) , insurance will only be successful if the event insured against is outside the control of the individual. In the case of tick-borne diseases, it would be difficult to distinguish avoidable from the unavoidable losses, so that the incentive to avoid risk is diluted, leading to resurgence and dynamic explosion of tick numbers and losses. Due to the need to inspect the losses closely, high administrative costs would be involved. It would also be difficult to set up probabilities of losses, much of it being 'uncertain'.

Given the other problems that confront the livestock sector, introduction of state insurance schemes would not make much impact on the allocation of resources in a tick and tick-borne diseases environment and is not justified at the present stage of development.[5]

FOOTNOTES

1. Headley (1972).. Economic entomologists distinguish this from the "damage threshold" which denotesthat level of control below which economic losses occur. This coincideswith the bio-technically efficient level of control, and is denoted by point Y in the diagram. In the case of the three-host R.app., such a level would be the 7-day rate of dipping or spraying in an acaricide with a long residual effect. In the case of the one-host Boophilus decoloratus, a three week interval would generally eliminate all the economic losses.
2. Ministry of Agriculture, Annual Report for Western Province,1978.
3. Ministry of livestock Development. Performance and Cost Cost Evaluation of the National Tick Control Programme and Some Consideration about Dipping Fee Collection Procedure. Working Paper by G.K. Njuguna and D.Stotz, Nairobi, 1980.
4. A former director of the Dept. of Veterinary Services in Kenya supports this when he urges the setting up of an insurance scheme against disease losses. See I.E. Mureithi. Disease Control and Agricultural Extension Services. Bul Epiz Dis Afric, Vol. 21, 1973.p.477.
5. There has been no insurance scheme in the livestock sector in Kenya in the past. A well-known credit-cum-insurance scheme in crop production has been the Guaranteed Minimum Returns (GMR) Scheme. This scheme was set up after the Second-World War under the Increased Production of Crops Ordinance of 1942. At that time it covered a wide variety of annual crops grown in the large-scale farm areas. This scheme has been in operation until early 1979, when the insurance component was abolished and the credit component replaced by a Seasonal Credit Scheme. It however had been applying only to maize and wheat. Under the scheme, farmers owning more than 6 ha. were advanced credit which covered the purchase of inputs in maize and wheat production. The credit was to be fully repaid if the harvest was good. If it, however, fell below a certain agreed minimum level, and it is certified that it was due to circumstances beyond the farmers control, part or all of the repayment is waived (Heyer et al.,p.231).

   The insurance component was abolished mainly due to the problems related to moral hazard, expectedly leading to abuse of the scheme by some farmers and officials.

CHAPTER FOUR

AN ECONOMETRIC ANALYSIS OF THE IMPACT OF THE ECF CHALLENGE ON CATTLE IMPROVEMENT AND TICK CONTROL.

4.1: Introduction

In this chapter, we apply econometrics to gauge the imapct of ECF challenge on, first, the breed portfolio of cattle kept in various districts in the country, and second, how the breed portfolio influences the number of farmers participating in tick control. The objective is to provide some empirical content to the economic policy issues that were raised in the last chapter. Moreover this is an important area of analysis on its own. It is improved cattle that account for most of the marketed milk production in the country, despite the Zebu (Bos Indicus) cattle comprising 90% of all adult female cattle in the country. According to Ruigu et al. (1976), about 85% of all the grade cattle are found only in 12 districts in the country : viz. Meru, Muranga, Kiambu, Nyandarua, Nyeri, Nakuru, Kericho, Transzoia, Uasin Gishu and Laikipia (there are 42 districts in the country). The large-scale farm sector accounts for about 60% of all marketed milk production.

Table 4.1: Percentage Distribution of the National Grade Cattle Herd by Type of Farmer.

	% Share
Large Scale Farmers	33.8
Small Scale : Grade	28.9
Zebu Crosses	13.4
Settlement Schemes	23.9
	100.0

Source: Ruigu et al.(1976),p.1.

It then becomes essential to gauge the extent to which ticks and tick-borne diseases, particularly ECF, influence this pattern.

As was argued in the last chapter, the presence of ticks and tick-borne diseases is expected to have a significant impact on the breed portfolio of cattle kept in an area. Due to the differential cattle breed susceptibility to tick-borne diseases, particularly ECF, ceteris paribus, improvement of cattle is only undertaken at a higher risk of mortality. This then becomes a conventional case of tradeoff between risk and higher returns from improved cattle. As is generally accepted, most farmers are risk averse and have concave utility functions of money yield.[1] They will therefore value grade cattle at less than their expected monetary productivity. As such, we expect the extent of ECF challenge in various districts in the country to negatively influence the proportion of grade cattle that is kept.

In the last chapter, we also singled out spread externalities as an important influence on the the extent of farmer participation in tick control. Farmers who keep the unimproved cattle have little incentive to participate in tick control, support cattle cleansing ordinances or the construction of communal control facilities,as the animals they keep are to a large extent immune to the major tick-borne diseases. Most benefits of control would therefore accrue externally to other farmers, particularly those who keep the improved cattle. Improvement of cattle leads to "internalisation" of most of the benefits from control. The higher productivity of the animals also raise the economic return to control efforts, justifying the farmers investment in [illegible] control measures such as fencing and internal water supplies. The higher collection of dipping fees also raises efficiency in the operation of cattle dips. We therefore expect a significant positive impact of the proportion of improved cattle in various districts on the proportion of farmers participating in tick control.

Besides ECF and other tick-borne diseases, other factors, independently or by facilitating the spread of ticks and the diseases, influence the proportion of grade cattle kept in various regions in the country, and the number of farmers participating in tick control. The factors that we consider important are discussed below.

1. Land Potential

Improved cattle are not only more susceptible to tick-borne diseases but are also less resistant to drought and heat, and are less hardy compared to the unimproved cattle. Agro-climatic conditions determine the quality and quantity of the grazing available to livestock, and are, in turn, influenced mainly by rainfall and temperatures. Grade cattle will only thrive in the medium and potential areas where good pasture is assured throughout the year.

Recalling the analysis in chapter I, the medium and high potential areas, c<u>eteris paribus</u>, face the highest ECF challenge. Høwever, the tick-challenge in different areas is influenced by the extent of tick-control, so that we do not expect this factor to influence our results "detrimentally" (in the statistical sense).

2. Land Tenure System

The establishment of private property rights to grazing land and water plays an important role in the decision to improve one's cattle and is an independent influence on the decision to participate in tick control. As Nsubuga (1973, p. 138) emphasizes

> Livestock improvement depends upon the adoption of improved methods of animal husbandry by the majority of stock owners. These methods necessitate enclosure to control stock movement to prevent the spread of disease; tick control by dipping or spraying and the development of improved water supplies.

According to the 1967 FAO Livestock Survey, whereas it is possible to improve crop production methods under a communal land tenure system, no comparable progress is possible in the case of animal production - "experience has indicated that only where consolidation and enclosure of land has taken place has productivity of live-stock taken place" (p.23).

A communal land tenure system not only facilitates the spread of the diseases, but has an inherent self-destructive mechanism which reduces the grazing land base necessary for improved cattle. Unrestricted ownership of land leads to a divergence between private and social evaluations of grazing land, leading to cattle population explosion, overgrazing and land denudation. It is perfectly rational for an individual farmer to maximize the number of cattle, even if the community would gain from a smaller aggregate herd and controlled grazing. An individual farmer has no incentive at all to improve pasture - by controlling the number of his animals.

In Kenya, registration and enclosure of land has another major function. It permits access of smallholders to credit. The distribution of credit to finance the purchase of grade cattle is regulated by availability of collateral security which farmers could offer. Land title deeds are the most favoured forms of security available to smallholders.

We therefore postulate that the extent of establishment of private property rights to pasture has a positive influence on the proportion of improved cattle in the various districts, and also on the proportion of farmers participating in tick control.

3. Availability of Communal Cattle Dips and Spray-Races.

Cattle dips and spray-races are the most favoured facilities of control, particularly by smallholders, on a cost-efficiency basis. They display scale economies in their operation. For example, according to estimates made by the Ministry of Agriculture (1979), the average value of acaricides in common usage in Kenya range from 71 cts to Shs. 1.90 per animal in private spraying. This is compared to only 16 cts to 31 cts per animal when a spray race is used, and 24 cents to 31 cents when a dip is utilized. However the initial capital cost of constructing a dip or spray-race is beyond the financial means of most smallholder farmers, while private spraying is both uneconomical in the use of acaricides and is not as efficient in reaching all parts of the animal. Most smallholders therefore rely on communal dips and spray-races, which charge fees averaging 18-21 cts per 'dipping' per animal (Duffus, p.29). This is well reflected in the following data collected by the FAO/UNDP survey in the country.

Tick Control Methods	% Smallholders in the Survey	% Large-Scale Farmers/ Ranchers in the Survey
None	27.5	13.0
Communal Dipping	57.6	16.9
Communal Spraying	1.8	0.7
Individual Spraying	0.1	42.7
Individual dipping	10.5	26.7
*Hand-dressing	2.5	0
	100.0	100.0

* Some cattle were subjected to hand-dressing in conjunction with the other tick-control methods, but mainly with individual spraying. The survey did not distinguish the use of power operated spray races from the use of a hand pump and bucket - mainly in smallholder areas.

Source: FAO/UNDP(C) (1975), p.21.

From the data above, more than 50% of the smallholders in the Survey used communal dips, while largeholders mainly relied on individual spraying and dipping.

The availability of communal dips and spray-races is therefore likely to be a major positive influence on the improvement of cattle and farmer participation in tick control, particularly in smallholder areas. Available evidence indicates that more than 50% of the national herd is in the hands of smallholders (Peberdy, p. 24).

4.2: The econometric model

The following equations are fitted to "explain":

(a) the proportion of grade cattle in various districts in the country,

and (b) the proportion of farmers participating in tick control in the districts.

GRADE = f(ECFCH, LDPTL, UNREG, DIPNO)

CONTROL = g (GRADE, DIPNO, UNREG)

where:-

GRADE = the proportion of improved to total cattle population in each district

LDPTL = the land potential of each of the districts

UNREG = the proportion of unregistered land, instrumental variable for the extent of communal grazing in the various districts.

ECFCH = the ECF challenge in the various districts
DIPNO = the total number of dips per 10,000 of the cattle population
and CONTROL = the proportion of farmers participating in tick control.

The two equations are estimated by the Ordinary Least Squares (OLS) method. Both linear and log-linear functional forms are examined for the best fit[2].

4.3: Data Sources

The equations are estimated for 35 of the 36 districts covered by the FAO/UNDP Survey undertaken in Kenya in the early 1970s. Marsabit, Turkana, Wajir, Mandera, and Mombasa districts are excluded from the analysis. Besides the data from the Survey, supplementary information is extracted from various issues of the Kenya statistical Abstract, Ministry of Agriculture (MOA) annual reports and from the general literature. To attempt to obtain consistency in the data used, only data relating to the 1972-75 period is used.

4.4: Measurement of Variables and Limitations

The proportion of improved (grade) cattle to total cattle population in each district (GRADE) is estimated from the 1973-74 provincial annual reports of the Ministry of Agriculture. The estimates correlate closely with those compiled by the Institute for Development Studies for the 1970 (1975, p. 9 - 31).

The FAO/UNDP Survey results on the proportion of cattle responding positively to the ECF serological I.H.A. test (a titre in excess of 1:1620) is here used to approximate the degree of tick and EC challenge in each of the districts considered (ECFCH). There are several possible objections to the use of this measure. Firstly, it does not incorporate the interseasonal factor in ECF challenge in a district. Cattle respond positively if the test is performed within the first six months of the animal contracting ECF[3], so that the proportion responding positively will vary from one period to another. Secondly, because improved cattle are more susceptible to ECF, a smaller proportion survive to be sampled, as evidenced, for example, by the relative proportions of Zebu cattle (33.9%) and exotic cattle (Ayrshire, 21.9%; Guernsey, 28.9% etc) sampled in the FAO/UNDP survey. Given these limitations, the data are used for lack of a better alternative, and because they conform closely with what is known of the epizootiology of ECF in the country (see Chapter Two). Moreover, the proportion of cattle responding positively to the ECF serological test was found highly correlated with the average number of ticks collected from cattle receiving no tick control.

Data on the proportion of high potential land in each district (LDPTL) are computed from the 1974 Statistical Abstract (p.102), where high potential areas are defined as receiving at least 857.5mm of rainfall per annum.

For the proportion of farmers participating in tick control in each district (CONTROL), we rely on data from the FAO/UNDP Survey. The Survey estimated the proportion of farmers in each district who professed to undertake some form of tick control in the survey period. The proportion will, admittedly, vary from year to year for each district, while the estimated proportions are most probably biased upwards - eleven districts had more than 95% of the farmers claiming to practice some form of tick control, with only one district (Garissa) having less than 10%. The national average was 72%. However the data conform generally with what is known about the relative intensity of tick control in various regions; the proportions being highest in Central and some districts in the Rift Valley Provinces and being below the national average for Nyanza and Western Provinces (FAO/UNDP(C), p.9) .

The number of completed dips and spray races in 1975 per 10,000 of the cattle population in each of the selected districts is computed to approximate the availability of tick control facilities (DIPNO) . It was not possible to separate operating from completed dips, while reliable estimates of the entire cattle population is available only up to 1971/72 (Statistical Abstract 1978, p.116).

Lastly, data on the proportion of smallholder unregistered land are compiled from the 1974 Statistical Abstract (p.5).

The following arethe data used in the regression analysis.

DISTRICT	% Proportion of unregistered smallholder land (UNREG)	Dips and Spray races per 10,000 of cattle population (DIPNO)	% proportion of improved cattle (GRADE)	% proportion of high potential land (LDPTL)	proportion %/of cattle responding to ECF IHA Test (ECFCH)	proportion %/of farmers practising tick control (CONTROL)
Bungoma	12.1	6	1.2	82	27.4	83.8
Busia	18.6	9	0.6	100	73.6	39.7
Kakamega	13.7	3	3.9	92	38.0	57.3
Kisii	11.0	2	7.7	100	40.7	76.3
Kisumu	49.8	1	1.8	94	62.2	16.9
Siaya	65.6	2	0.6	94	57.5	11.4
S. Nyanza	66.9	0.5	0.1	99	83.0	22.9
Baringo	89.0	20	7.8	16	29.2	85.3
E. Marakwet	52.3	7	25.4	38	71.6	90.1
Kajiado*	57.1	2	0.1	1	15.4	54.5
Kericho	23.0	9	51.6	78	13.7	99.3
Laikipia	8.1	12	11.7	13	13.2	100.0
Nakuru	1.9	47	44.0	41	18.1	100.0
Nandi	80.8	5	27.6	85	42.5	100.0
Narok	69.6	1	0	79	40.1	52.0
Samburu	84.1	0.3	0	7	8.7	32.5
Transzoia	0	23	80.0	84	26.6	100
U. Gishu	0	35	45.0	87	40.4	100
W. Pokot	92.3	6	0.8	20	34.1	35.7

........../2

DISTRICT	% Proportion of unregistered smallholder land (UNREG)	Dips and Spray races per 10,000 of cattle population (DIPNO)	%Proportion of improved cattle (GRADE)	%Proportion of high potential (LDPTL)	proport-ion % /of cattle responding to ECF IHA Test (ECFCH)	proportic % /of farmers practising tick control (CONTROL)
Muranga	0	22	47.0	78	39.8	98.2
Kiambu	0	23	76.8	78	27.2	98.0
Kirinyaga	0	15	25.7	67	52.0	98.0
Nyandarua	0	13	83.0	75	3.0	100.0
Nyeri	0	15	68.0	49	53.8	98.0
Embu	69.3	9	7.6	66	21.7	85.4
Isiolo	99.1	0.3	0	1	17.6	23.1
Kitui	52.4	1	0.1	12	28.5	37.1
Machakos	8.9	7	1.6	50	12.7	87.0
Meru	60.8	8	5.5	10	16.1	84.8
Garissa	99.8	0.1	0	0	1.8	0
Kilifi	55.8	2	9.9	8	24.6	65.1
Kwale	64.2	7	0.5	15	12.7	83.9
Lamu	2.8	6	0.1	1	15.6	15.0
Taita	10.0	8	2.7	2	14.9	50.0
Tana River	37.5	0.1	0.1	2	4.4	25.0

* The FAO/UNDP Survey data in the last two columns distinguished South and North Kajiado. We calculated an average for the two to get data for Kajiado.

4.5 Regression Analysis Results

The table below presents the simple correlation coefficients matrix of the variables in the analysis

Table 4.2 Correlation Coefficients (Linear Functions)

	UNREG	DIPNO	GRADE	LDPTL	ECFCH	CONTROL
UNREG	1.000					
DIPNO	-0.528	1.000				
GRADE	-0.557	0.647	1.000			
LDPTL	-0.388	0.204	0.371	1.000		
ECFCH	-0.021	-0.030	-0.023	0.607	1.000	
CONTROL	-0.512	0.632	0.662	0.278	-0.068	1.000

Table 4.3 Correlation Coefficients (Log-Linear functions)

	Log UNREG	Log DIPNO	Log GRADE	Log LDPTL	Log Log-ECFCH	Log-CONTROL
Log UNREF	1.000					
Log DIPNO	-0.598	1.000				
Log GRADE	-0.628	0.818	1.000			
Log LDPTL	-0.344	0.561	0.614	1.000		
Log ECFCH	-0.068	- 0.306	- 0.254	0.631	1.000	
Log CONTROL	-0.307	0.627	0.568	0.689	0.434	1.000

The following are the linear and log-linear equations from the regression analysis.

DEPENDENT VARIABLE	INDEPENDENT VARIABLES					R^2	DF
GRADE		ECFCH	LDPTL	DIPNO	UNREG		
	9.222	-0.271	0.2370	1.198	-0.136		
	(0.94)	(1.32)	(1.89)[c]	(3.27)[a]	(1.12)	0.54	30
	1.09	-0.3240	.293	1.3901			
	(0.16)	(1.61)	(2.54)[b]	(4.28)[a]		0.52	31
	12.653	-0.4928	0.4306				
	(1.69)[c]	(2.02)[b]	(3.13)[a]			0.24	32
Log GRADE		Log-(ECFCH)	Log-(LDPTL)	Log-(DIPNO)	Log-(UNREG)		
	-332	-0.426	0.424	1.0419	-0.1600		
	(0.31)	(1.06)	(2.24)[b]	(4.36)[a]	(1.61)	0.74	30
	-0.633	-0.552	0.462	1.241			
	(0.59)	(1.36)	(2.40)[b]	(5.91)[a]		0.72	31
CONTROL		GRADE	DIPNO	UNREG			
	52.853	0.485	0.977	-0.1267			
	(5.29)[a]	(2.24)[b]	(1.84)[c]	(0.86)		0.52	31

DEPENDENT VARIABLE	INDEPENDENT VARIABLES				R^2	DF
		Log(GRADE)	Log(DIPNO)	Log(UNREG)		
Log (CONTROL)	2.812	0.1277	0.5341	0.0728		
	(6.60)[a]	(0.93)	(2.19)[b]	(0.87)	0.42	31
	2.727		0.695	0.0494		
	(6.57)[a]		(4.05)[a]	(0.62)	0.40	32

Key:

a Coefficient significant at the 99% level

b Significant at the 95% level

c Significant at the 90% level.

The figures in parentheses are the Student's "t-statistics"

DF = Degrees of Freedom

4.6: Discussion of the Results

a). The Improvement (Grade Cattle) equation

The equation is to a large extent successful in "explaining" the inter-district variation in proportion of grade cattle kept, given the highest R^2 equals 0.74 (log-function). The signs of coefficients of the variables are as was expected, so that a higher land potential facilitates improvement of cattle, while the ECF challenge and the proportion of unregistered land affect the process negatively.

When we examine the "t-statistics", the availability of dips and spray races variable is consistently the most significant, at the 99% level. The other significant variable is the land potential (LDPTL) coefficient, which is significant at 90% when all the variables are included, but increases when some of the other variables are omitted from the equation. The ECF challenge variable only takes the third place in terms of significance, followed by the extent of land registration.

It is not surprising that the relative availability of dips and spray-races in different areas of the country has a most important influence on the degree of cattle improvement. This is consistent with an observation by Hopcraft (1976, p.62) that in some districts an "increase in cattle dips and the number of cattle dipped has resulted in virtual explosion of grade cattle". The mechanism through which this variable influences the degree of cattle improvement is well explained by a MOA Working Paper reviewing the Kenya Tick Control Project.[3] It notes that some districts have performed poorly relative to others. For Kisii district, it cites the following major reasons, which can be generally applied to most other areas :

> (i) the area is not adequately covered with dips. This implies that many farmers are not capable (sic) to bring their cattle for dipping at all or infrequently because the distance from the farm to the dip site is too far. (ii) There is no immediate economic incentive for Zebu owning farmers to build more dips because the majority of the cattle population consists of Zebu cattle (89%) which show a certain resistance against tick-borne diseases.

Therefore the paper notes some form of low equilibrium trap in such areas, and proposes that the Project should ensure an adequate dip coverage in the affected areas to break the cycle.

In Kenya, communal dips and spray-races are generally supplied through self help. Even when external assistance has been available, the local community is required to raise a large proportion of the initial capital expenses. The Tick Control Project initiated in 1976 has in the past selected smallholder project areas on the basis of adequacy of existing dips, and has not incorporated dip-building in the programme. Several factors will influence the supply of dips in different areas. First is the felt need for tick control, related mainly to productivity and susceptibility to tick-borne diseases in the cattle kept. This is evidenced by a high positive linear correlation between the number of dips and spray-races and the proportion of improved cattle (r = 0.648). Apparently ECF challenge plays only an indirect role in influencing the demand for cattle dips, as indicated by a perverse linear correlation with dips (r=-0.030). The availability of tick control facilities, and a high incentive to use them because of grade cattle has reduced the influence of the tick challenge over time. Secondly, to translate the felt need for dips to reality, the community's ability to finance their provision is an important factor. Therefore, the more developed areas are able to tax themselves more in the provision of the community needs. Thirdly, given that dips and spray-races are basically public goods, socio-political factors are important b). The Control Equation

The three variables GRADE, DIPNO, and UNREG are less successful in 'explaining' interdistrict variation in farmer participation in tick control, explaining only 52% of the variation. The signs of the coefficients in the linear equation which has the highest explanatory power, is as was expected. As such, it supports the obvious assertion that grade cattle and availability of tick control facilities give incentive and enable farmers to participate in tick control. Unregistered land and communal grazing and watering facilitate spread externalities in tick control, and reduce the farmers incentive to undertake it.

The econometric problem of multicollinearity which is evidenced by the high correlation coefficients between GRADE and DIPNO and inconsistent movement of the coefficients prevent us gauging the relative significance of the variables. A large and highly significant constant term implies that major explanatory variables were left from the equation, or may reflect the data problems that were noted earlier.

FOOTNOTES

1. Given utility U(Y), where Y is money yield, $U'(Y) > 0$ and $U''(Y) < 0$.

2. To permit logarithmic transformation of variables with some observation values equal to zero, we added to all the observations of the variable value 0.01. This should have little or no impact on the final results as the variable values are general estimates. For a rigorious justification of the methodology, see

   Ryan, T.C.I. Non Linear Transformations and Treatment of strictly non positive values of variables. Institute for Development Studies, University of Nairobi, Technical Paper No. 9, Nairobi, 1974.

3. Cunningham, M.P. - Personal Communication.

4. Ministry of Livestock Development. Performance and Cost Evaluation of the National Tick Control Programme and Some Consideration about Dipping Fee Procedures. Working Paper by G.K. Nyuguna and D. Stotz. Nairobi, Jan. 1980.

CHAPTER FIVE

QUANTITATIVE ECONOMIC ANALYSIS OF DAMAGES AND OTHER LOSSES CAUSED BY TICKS AND TICK-BORNE DISEASES (PARTICULARLY ECF) AT THE FARM LEVEL.

5.1: Introduction

This chapter attempts a quantitative assessment of financial damages and losses caused by ticks and tick-borne diseases, particularly ECF, to the farmers. The estimated values are then compared to the costs of control, by the available methods, at the farm level. Needless to say, the analysis is just indicative, showing the order of magnitudes involved. Fine estimations are hampered, firstly, by inadequate field information on the spatial and temporal impact of ticks and tick-borne diseases on the livestock economy in various regions of Kenya and, secondly, by lack of reliable benchmark data from which to gauge the impact. Consequently, the paper analyses a model herd of 2,000 cattle. The herd size is arbitrarily chosen, but has been used by some authors as the average number of animals that would be efficiently served by one communal dip.[1] The herd is maintained in a cool and wet high potential area, where tick-borne diseases, particularly ECF, are enzootic in the absence of tick control. It is kept by smallholders, potentially for both beef and milk production. We start from a situation where no tick control is undertaken, and then trace the production losses that would be alleviated and the increase in herd productivity likely to occur when efficient tick control is instituted. The benefits derived in this way are then compared to the costs that the farmers incur in tick control, mainly in the form of spraying expenses, dipping fees, and in building and maintaining communal dips in self-help schemes.

Since most of the benefits of tick control accrue in the future, the capital budgeting principles are applied, involving discounting future benefits and costs to get the present values. Discounting takes into account the time value of money. For discounting future costs and benefits, we select an interest rate of 15% as representing the rate of return farmers would expect from financial investments in agricultural activities.

Section 2 reviews and presents the available evidence of the impact of ticks and tick-borne diseases on the cattle productivity. Section 3 provides the benchmark data on the herd productivity coefficients and the price parameters used in the subsequent analysis. Section 4 analyses the expected costs of control at the farm level. Section 5 presents and discusses the results, while Section 6 draws implications for the profitability of tick control to the society and economy as a whole.

5.2: The Impact of Ticks and Tick-borne Diseases on Cattle Productivity.

As was indicated in Chapter One, the main economic effects or the production losses caused by ticks and tick-borne diseases take three forms:

1. Cattle mortality
2. Retarded growth and lowered productivity of the surviving animals as a result of the debilitating effects of tick infestation.
3. The opportunity cost of being made to keep the less productive unimproved cattle, this impairing

both the technical and economic efficiency in resource allocation in the cattle economy.

There has been little field work to establish the extent of these losses in Kenya, probably reflecting the difficulties that would be involved in collecting data on cattle deaths and establishing the other economic losses at the national level. The only comprehensive study is the FAO/UNDP Survey, which was concerned with establishing "facts that would assist the government to make policy decisions on how to improve its tick control programmes, both technically and socio-economically". It however fell short in the establishment of the actual losses caused by ticks and tick borne diseases, but

indicated that 30.1% of the national herd responded positively to the IHA serological test, implying that they had been infected with ECF at one time or another in the past.

Cattle Mortality

In tick-endemic areas where there is no tick control and only the indigenous cattle are kept, tick-borne diseases cause mortality losses only in calves - where a calf is generally defined as an animal less than one year old, or in field-work, the unweaned animals. Estimates that have been made of the calf mortality levels in such areas range from 10% to 50%. The mortality level declines to about 5% following efficient tick-control (Ferguson, p. 73).

Several studies have been undertaken to establish actual mortality levels in several areas in East Africa. Barnett (1957) in one of the most detailed field studies done in Kenya, selected two areas in Nyanza Province - at Lela and Bungoma. At Lela, he observed 461 Zebu calves over a 4 - year period. On average, 28.6% of the calves died annually, with no significant variation over the years. A similar proportion was observed at Bungoma, where an average 29% of calves died annually. In the two areas, ECF contributed 8% to the total calf mortality. Barnett then pointed out that this agreed with the general observation of the mortality levels over a large area of the Nyanza Province. Grade cattle introduced in the two areas all died of ECF and other tick-borne diseases a few days after exposure. All the (Zebu) calves which survived the first 12 months or more were found to be solidly immune to ECF. Dipping was later introduced at Bungoma on a two-week interval. The mortality rate fell to an average of 7.4% for the two and a quarter years following tick control, before increasing again when dipping broke down as a result of poor management of the facility.

McCullock (1968) undertook a similar survey in Sukumaland, Tanzania. He entered the names of owners and stock in a register and subsequently visited them every four months for several years, checking actual livestock numbers against gains and losses. He found that, in the ECF enzootic regions, 45.7% of the calves, and 9.0% of adult were lost through mortality, with ECF being the major causal factor. In the clean regions, a lower proportion of cattle died, being only 4.3% for calves and 5.1% for the adult cattle.

In Uganda, the available evidence of the cattle mortality levels in tick-borne diseases endemic areas is summarised by Ferguson (1971) and the 1967 FAO Livestock Survey. At Ongino in Teso District, the calf mortality rate stood at 25.7% when no tick control was practiced, but fell to only 3.3% after the control (Ferguson p. 175). At the Bunyoro Ranching Scheme, mortality was reduced by dipping from around 50% to 12% in the early 1960s (FAO, p. 99). In other areas, mortality levels prior to tick-control were 33.8% for the Ankole Land Use Unit, and 37.7% at the Serere and Kyoga counties. More recently Oteng (1976) has estimated that theileriosis, which is closely associated with the distribution of the tick-vector, R. App., causes an annual loss of 50% of the calf crop in the enzootic areas in Uganda. Intensive tick control has reduced the rate to 5% annual mortality loss.

From the foregoing, we take a 30% calf mortality loss from tick-borne diseases as typical in a tick-endemic area. This would be reduced to 5% following efficient tick control.

In the high potential areas, efficient tick control *ceteris paribus*, will permit farmers to improve their livestock, but at the expense of a higher susceptibility to tick-borne diseases. It is important to emphasize that improvement of cattle and tick control is an all-or-nothing phenomenon. Losses in improved cattle occur when tick control is badly executed rather than due to lack of it. Earlier in the paper, we referred to a study by the Veterinary Department which found that, in the study area 28% of heifers born through AI never reach maturing age because of mortality from tick-borne diseases. We use this proportion in our analysis and extend it to all ages of improved cattle where tick control and facilities are not adequately managed. We postulate that efficient tick control can reduce the proportion to only 5% of the animals.

Impaired productivity of the surviving cattle population.

As was stated in Chapter One, a heavy tick infestation impairs the productivity of the surviving cattle population in tick-borne diseases endemic areas. Ticks lower the value of hides, lead to blood loss and anaemia, and stunt the growth of calves that survive an infection. Heavy tick infestation also causes irritation leading to licking, at the expense of the feeding of an animal. Only a few studies have attempted to quantify this category of losses. For example, the Cattle Tick Commission in Australia (1975) estimated that for Queensland conditions, liveweight losses from the feeding of an average 30 ticks to be about 6.8 kg per animal per year and discounted the value of "ticky" hides by several cents.

In this paper, we adopt the approach that reduced condition of cattle from tick infestation mainly influences milk production. This is not an unrealistic approach. Tick control has often been associated with increases in milk production, even for the indigenous cattle. This may be due to several reasons (Ferguson, p. 176). The improved health and condition of cattle in a disease endemic area after tick control induce a higher milk output from the cattle. A heavy tick infestation hinders and stunts the growth of calves, and thus reduces their potential milk output. For evidence, an experiment at the Naivasha Husbandry Research Station found a significant positive correlation between the growth of a calf and milk production from a cow in the first 100 days of its first lactation, even after allowing for the calving age.[2] The heifer would also have a large size. Moreover, a reduced calf-mortality permits a larger lactation period, particularly with indigenous cattle which are milked with the calf at foot. Tick control also reduces the calving interval. For adult cattle, Omuse (1978, p. 182) notes that in the case of ECF, farmers report an animal in extreme "depression, not eating, lachrymating, and in lactating animals a drop in milk production". If they survive, they are characterized by unthriftness, weight loss, "diarrhoea inappetence and failure to gain even the original weight before infection for at least 6 months" (Oteng (1976), p.21). Therefore, reduction in the infestation rate is likely to be accompanied by increased milk output from the lactating cows.

In absense of better information, the analysis uses the assumption by Ferguson (1971) that tick control would induce an increase in milk output from indigenous cattle by 20%, though with some time lag.

<u>The opportunity cost of forgone development that would have been motivated in the absence of ticks and disease.</u>

A major opportunity cost of ticks and tick-borne diseases is that they discourage improvement of the indigenous cattle in the high potential areas. In such areas, improved cattle will not survive without tick control. This is a cost in that improved cattle have a higher productivity, with upgrading of indigenous cows expected to increase milk production by about 300 per cent "with a modicum of extra feed and better care" (Hopcraft, p. 23).

In Kenya, the MOA estimates the grade cow population will increase by 5.3 percent per annum, while the Zebu herd is expected to grow at 2% per annum in the 1980s. The implied growth rate in the total cattle population may be optimistic in view of the existing overstocking and increasing agricultural encroachment onto grazing land. In the high potential areas, the genetic improvement (upgrading) of the Zebu cattle is expected to continue at 10.7% (Ruigu, p. 100).

In the analysis, we subject different rates of Zebu cattle improvement to sensitivity analysis, starting with the spontaneous use of artificial insemination (AI) alongside effective tick control. To allow for the fact that improved cattle require more grazing land, feed requirements and higher animal husbandry standards, we permit one improved (grade) animal to substitute for two unimproved (Zebu) animals in the analysis.

For the initial composition of the herd model we rely on the results of the 1974/75 Integrated Rural Survey on smallholdings. The following are the data on the composition of unimproved cattle in smallholder areas, as analysed by the survey.

	Percentage of the Total Herd
Calves	16.4
Heifers	16.5
Cows	36.1
Steers	3.6
Bulls and Oxen	27.4
	100.0

Source: 1978 Statistical Abstract, p.141.

5.3: Technical Productivity Factors and Price Parameters Used in the Analysis.

As said in Section 3.1, we use the information on the structure of the Kenya national cattle herd. However, there is no agreement in the literature on several of its characteristics. Probably the most comprehensive analysis of these is done by Peberdy (1969). His results are used extensively below.

He (P.11) estimates the average milk production for the indigenous Zebu cow per lactation at 272 litres, with the calf taking an equivalent amount of milk. This is low when compared to estimates by other authors. For example, Stobbs (1967) estimates a total output per lactation of 772 litres. It is however high when compared to, say Ruigu's (1978) estimates of 120 litres to the farmers, with the calf taking 300 litres. Peberdy (p.20) estimates the national herd to have a national calving percentage of 61%. This is consistent to the findings of a Preinvestment Survey in Taita, which showed a calving percentage at 62%. This was however higher for the more organised ranches - at 69% (Simpson, p. 7). In the subsequent analysis, Peberdy's estimates are used. We apply a higher rate to improved cattle of 70%.

Milk is valued at the KCC price which generally acts as the floor price that the farmers get. This price was at Shs. 1.32 per litre in 1979. Allowing for an approximate cost of transportation of 10 cts and cess deducted by the KCC at 3 cents (MOA, 1979), the farmer receives about Shs. 1.19 per litre.

The most difficult loss to value is the Zebu calves that die in a tick-borne diseases endemic area as there is no formal market for calves in smallholder agricultural areas. A conceptually appealing approach would be to compute the discounted net value of a Zebu calf's expected future output, distinguishing the bull from the heifer calves. However this approach would suffer from lack of adequate information on the various production parameters. The other alternative is more practical and has been extensively used in the literature. It involves estimating an average weight for the Zebu calves, and valuing it at the prevailing meat prices. Ferguson (1971) used the weight of an average full grown animal, of 227 kg. Peberdy estimates an average weight of 60 kg. In the analysis, we adopt a more conservative estimate by Aldington (1968) of 36 kg, valued at the average liveweight price paid by the KMC in 1978[3]. For the improved cattle, we apply the rates of Shs.400 per calf and Shs. 1000 for the adult cattle. This probably undestates the actual value of female cattle and overstates the value of the male due to the prevailing relative prices of milk and beef, and because some of the indigenous and improved breeds are relatively poor performers as beef cattle. However prices of beef are expected to increase significantly in the 1979/83 plan period relatively to the price of milk (p.265), consumer prices and input costs (p.209).

5.4: Costs of Control

The individual farmer is postulated to have three alternative methods in tick-control.

1. The farmer may use the available communal dipping facilities and pay the dipping fees. Revenue from the fees is then used to cover the operating, cleaning, and replenishment costs incurred in maintaining such facilities. The amount of dipping fees paid by the farmers vary from one area to another, and average 18-21 cents per animal per dip (Duffus, p.21). The only other financial expense the farmer incurs is on the labour involved in mustering the animals for dipping. We assume a third of a man-day is spent on such dipping operations. The labour is valued at the 1977 legislated minimum wage rate of Shs. 6.75 per day. It is not possible to quantify the production losses that ocur when animals are moved long distances on hoof to the tick control points.

The average number of cattle per landholding will vary from area to area, depending on the population pressures, land potential and the existing land tenure system. The 1974/75 Integrated Rural Survey estimated 4 animals per landholding in

Central Province, 9 in Nyanza, 5 in Western, etc, and an overall average of 7 animals in the smallholder agricultural areas.[5]. In this paper, we adopt the fairly conservative estimate of 5 animals per landholding.

2. Alternatively, the farmer may undertake the private spraying of his animals. Spraying carries less danger of injury to cattle, particularly the improved ones, and avoids loss of condition from movement to dips. It is also more flexible, requiring fresh acaricide every time and therefore making it easier for the farmer to change to the most suitable acaricides without having to lose large quantities of dip wash as with cattle dips. However, its effectiveness depends largely on the person doing the spraying.

In this case, we assume the farmer uses a manually operated pump, requiring a combined one-third man-day per week (as "bucket and pump" spraying cannot be done by one person). The wage rate of Shs. 6.75 per man-day is again applied.:

The price of a hand-pump will depend as its quality. The MOA (1979) distinguishes the following types:

	Shs.
Hand Sprayers	
plastic hand pump	640.00
Hand pump sprayer	880.00
Hand pump (local) 5 litres	245.00

The farmer is assumed to purchase the cheapest sprayer, along with a 10 litre bucket costing Shs.31.00. The cost of acaricides used is estimated in the same document (p.36), when the farmer purchases the acaricide in less than 500 ml. packets:

Acaricide	Packs Available	Cost per Packet	Remarks	Cost per Treatment per Animal
		Shs.		Shs.
Delnav	100ml.	22/50	Diluting approx. 10ml. per 20 litres of water and apply 10 litres to each animal	1/10
Coopertox	350ml.	19/65	Use approx. 65ml. per 20 litre debe Apply 10 litres per animal.	1/90

According to the figures, the farmer uses the organophosphorous compound, Delnav DFF, which is the

> material of choice on a cost efficiency basis. It has residual properties and a relatively low exhaustion rate so that the maintenance costs are low (FAO/UNDP(a), p.47).

3. The last possibility considered is the use of a cattle dip, which is constructed through self-help, and farmers expected to contribute according to the number of cattle that they possess. A crucial requirement in the construction of a cattle dip is the availability of a permanent water supply. In the analysis, we

assume that a permanent water supply is available in the area, and that the cost of connecting the supply to the dip site is included as part of the initial capital cost - this is taken to be Shs. 25,000 for a standard 3000 gallon dip, and including the cost of acaricide in its initial fill of dip wash. As in the previous section, we rely on estimates made by the MOA (1979, p. 36) for the value of acaricides needed. It is postulated that the acaricide is purchased in 5 litre packets

Acaricide	Cost Shs.	Remarks	Cost of Treatment per animal Shs.
Delnav DFF	660/45	Initial fill at 455ml. per 1000 litres of water, and replenishing at 1:1500	-/66 per litre of initial full wash and -/19 per head dipped
Coopertox	137/45	Initial fill at 1 litre per 300 litres and replenishing at the rate of 1:200	92 cents per litre of initial fill wash and 28 cents per animal dipped
Supamix DFF	1057/65	Initial fill at 1 litre for 2200 litres of water and replenishing at 1:1280	9.6 cents per litre of initial fill wash and 33 cents per head dipped

Delnav DFF is the one that is used. The dip attendant is of the standard of a "farm clerk" and earning the legislated minimum wage (1977) of Shs. 315 per month. To these is added the costs the farmers incur in mustering the animals to the dips. This is postulated to be the same as for private spraying.

5.5 Results and Discussion

At this stage it is essential to reiterate once again that the estimates indicate only the order of the magnitures involved in the quantitative analysis of costs and benefits of tick control in a tick and diseases endemic area. The estimates reflect the assumptions stated and the herd projections that have been made. Consequently, the discussion will be concerned mainly with the relative rather than with the absolute values.

The herd projections and calculations for the results are presented in the appendix. The following are the estimated present value of costs and benefits of tick control to the farmers, per animal, in the 2000 - animal model herd, discounted at 15%, over a ten-year period, and accompanied by spontaneous use of artificial insemination for all the calves borne:

Table 5.1: Discounted Benefits of Effective Tick Control per Animal in the 2000-Cattle Model Herd over a Ten Year Period, with Spontaneous Adoption of AI

Increase in milk production from the indigenous cattle	Shs. 121.70
Alleviated Mortality loss	Shs. 372.10
Increase in milk production from the introduced improved cattle	Shs. 152.60
TOTAL	Shs. 646.40

Table 5.2: Discounted Costs of Tick Control per Animal in the 2000- Cattle Model Herd over a Ten- Year Period with Spontaneous Adoption of AI.

		Shs.
1.	Dipping fees and mustering costs	172.30
2.	Construction and maintenance of a cattle dip, plus the mustering expenses incurred by the farmers	186.52
3.	Private 'pump-bucket' spraying	366.95

Based on these results, it is quite evident that high returns accrue to farmers from efficient and effective tick control, and spontaneous use of artificial insemination, and any of the methods of control considered would be justified in financial terms. The farmer expects about 2 to 4 shillings from every shilling spent in the construction, maintenance and/or use of a communal cattle dip and private spraying.

Sensitivity Analysis of the Benefits

Sensitivity analysis is used in cost-benefit analysis to gauge how the results would be affected by changes in the assumptions relating to the most important and the most uncertain variables. The computed benefits above are admittedly sensitive to the herd projection model adopted and the assumptions made on the mortality level, increase in milk production and speed of cattle genetic improvement following effective tick control.

Due to the time constraint, it is not possible to gauge how responsive these results are to many of these assumptions. Nonetheless, we analyse further the assumption on the degree of improvement that is adopted, which we consider as the most crucial and uncertain variable determining the size of benefits resulting from effective tick control.[6]

The magnitude of benefits resulting from tick control is most sensitive to the spread of cattle improvement that is adopted. If, instead of the spontaneous use of artificial insemination (AI), farmers accept it only gradually (we assume six years), the benefits from efficient tick control decline by over 28%, holding all the other assumptions constant.

Table 5.3 Discounted Average Benefits Per Animal from Effective Tick Control When the Farmers take Six Years to Fully Accept the use of AI.

	Shs.
Increase in milk output from the indigenous Zebu cattle	164.80
Alleviated mortality loss	231.90
Increase in milk output from the improved cattle	67.90
	464.60

The costs of control also increase because of a higher use of acaricide. As it may be recalled, we are substituting two indigenous Zebu animals for one improved to account for the higher animal husbandry standards required in maintaining improved cattle. Therefore the herd size declines with a higher level of improvement.

When for one reason or another genetic improvement of cattle is not expected following effective tick control, the magnitude of the benefits decline even further.

Table 5.4: Discounted benefits of Effective Tick Control with No Genetic Improvement of Cattle

	Shs.
Increase in milk output from the indigenous cattle	171.60
Alleviated mortality	54.70
	226.30

Nevertheless, even with such a pessimistic assumption for the high potential areas, construction, maintenance and/or use of communal cattle dips yield a positive net present value, even though a low one, and despite the use of a high interest rate (expected rate of return) in discounting future benefits and costs.

Table 5.5: Discounted Costs of Effective Tick Control for a 2000 - Animal Indigenous Herd Without AI

	Shs.
1. Dipping fees and mustering costs	189.00.
2. Construction and maintenance of a cattle dip plus the mustering costs	202.45
3. Private "pump-bucket" spraying	459.95

However, private spraying apparently becomes an uneconomic proposition to the farmers and ceases to be a viable alternative in tick control. There is some scope for reducing these costs of control. Where there is a well marked seasonal climatic pattern and a dry season, cattle, particularly the unimproved, may be treated only in the wet season, when the R. app. and other tick vectors are most active. This would have a favourable impact on the benefit-cost ratio achieved by the farmer - through a lower cost of acaricides and mustering labour. This also helps to delay the onset of resistance of ticks to acaricides, and thus boosting the social desirability of this strategy of control.

From the relative costs of control, cattle owners will only undertake private spraying when there is no adequate number of communal facilities, or when their management is poor - so that there is risk of mortality loss despite the dipping. However dipping may be associated with additional losses which we were unable to incorporate in the analysis. When improved cattle are of a high cross, a drive over long distances on hoof is likely to result in a large drop in milk output. There is also the danger of physical injury to the animal, as well as being exposed to other communicable diseases at the dip centre. These potential losses may more than exceed the financial economy in cattle dip use. For example, Zalla and Harmon (1974, p. 34) noted that 90% of the farmers in Vihiga, Kakamega District, who owned grade cattle sprayed their animal, rather than dipping them despite the availability of well managed dips locally. Some of the farmers were paying Shs. 1/= per animal to itinerant sprayers, rather than 25 cents dipping fees.

In the analysis, financial profitability of tick control to farmers should not be interpreted as the role indicator of the ability and willingness of farmers to undertake tick control. All the methods of control involve cash expenditures before the benefits from tick control are realised. Therefore, tick control is likely to be crucially influenced by the relative available of cash by farmers in different seasons. It may also be hampered by labour bottlenects in the peak seasons of planting and harvesting in the high potential areas of the country. In such circumstances farmers are likely to consider the relative profitability of different agricultural enterprises in allocating the scarce economic resources.

Moreover, the farmers perceived benefits of tick control may not coincide with the mathematical calculations that have been made. The major factors influencing the farmers perceived benefits have been analysed in Chapter Three, and include risk and risk aversion in their behaviour (so that they will value improved cattle at less than their expected productivity in a tick-borne diseases endemic area), widespread externalities in tick control, and ignorance. The analysis in Chapter Three, therefore, advocated government intervention to help reduce the risk from tick-borne diseases, to internalise externalities, and provide extension services and general information on the expected costs and benefits of tick control.

5.6: Implications For Social Profitability of a Tick Control Project.

To appraise a tick control project from the society's point of view, two major adjustments are required. The first involves the identification of all the costs and benefits of tick control to the economy. These should include the costs that the farmers do not incur, and therefore are not incorporated in the previous analysis. For instance, farmers get free artificial insemination services, subsidised veterinary services and free land on which to build cattle dips. The second major adjustment relates to the price parameters that are used. Due to various imperfections in the market mechanism, particularly in the less developed countries, market prices may not adequately reflect the opportunity cost of inputs and the value of output from a project. The 'market failures' may arise from the existence of monopolistic and monopsonistic markets, government taxes and subsidies, government regulations (eg. minimum wages and prices control), externalities, economies of scale, and so on. We have then to correct the market prices for the distortions so that they reflect the social values. The adjusted prices are then referred to as "shadow" or "accounting prices". The shadow prices may also be used to reflect the government objectives and social dogmas.

Two dominating approaches are used for adjusting these prices. They are the UNIDO and the Little and Mirlees (OECD) methods.

The UNIDO approach uses the prevailing market prices as the benchmark for the adjustment so that they reflect the social benefits and costs, and the national policy objectives. The principle for the valuation of a projects output derive from classical utility theory, and considers the willingness of the purchaser to pay for the output. When the output is import-substituting, it is then valued in terms of the opportunity value of the saved foreign exchange. If exported, it is valued in terms of the earned foreign exchange.

Inputs in the UNIDO approach are valued in terms of the opportunity cost of the resources that go into the project. If an input is imported, or is a potential export, its value is measured by the sacrifice of the foreign exchange that is used.

The Little and Mirlees(OECD)method values goods and services in terms of their border prices - what they are worth at the/international borders of the country concerned. The numeraire in the approach is the foreign exchange rate, as the method relies on the world price as a reflection of the true opportunity cost of an input and value of an output of a project. Goods and services are put to two categories : the traded and the nontraded. Tradables are or can be imported or exported at the margin. Nontradables cannot be traded for various reasons such as high transport costs. This category includes electricity, construction work, domestic transport etc. Nontradables are generally valued in terms of cost of goods and services which go towards their production. By repeating this process, it is possible to express the value of these goods in terms of traded goods and labour. Like in the UNIDO approach, labour is valued in terms of its opportunity value in alternative employment.

Despite applying different methodologies, the two approaches in social appraisal give essentially similar results (Gasputa, 1972).

In a tick control project, several prices would require adjustment from the existing prices. Probably the most crucial are the prices of meat and milk, which are determined institutionally, rather than through market prices, and mainly handled by monopsonistic marketing agencies. Other crucial adjustable prices are the cost of acaricides,labour and construction materials. This paper, due to various constraints noted earlier,is unable to undertake its own adjustments. Nevertheless, it is unlikely that these adjustments are large enough to offset the favourable benefit-cost ratios noted in the previous section, and may instead boost the social profitability of a tick-control project over the private profitability to farmers.

As an illustration, the following assumptions are made to indicate the analysis involved. Spontaneous adoption of AI is again adopted. From estimates of scheme-specific costs of the Kenya National Artificial Insemination Service by Hopcraft (1976, p.191), we estimate the average cost per insemination at KShs.14.60.[7] Two inseminations are required for every conception and improved calf born. We set the value of other supporting services arbitrarily at Shs. 3 per animal. Scott et al. (1976) have estimated accounting prices for a wide range of products in Kenya, using mainly the Little and Mirlees method. The following are some of their estimates of the ratio of accounting prices to market prices in rural areas which are used in subsequent analysis:

	Estimated Ratios of Accounting to Market Prices.
Milk	1.00
Meat	1.16
Building and Construction	0.80
Artificial Insemination	0.79
Dip and Sprays (acaricide)	0.90

They further estimate the shadow wage of a regular worker on a small farm at K£41 p.a., and £55 on a large farm (p.91 and 100). In this case we use an accounting ratio for unskilled labour of 0.5. They select (p.48) an accounting (shadow) rate of interest of 10%, which lies between the rate of return noted in the private sector and in some public sector projects - about 15% - and the "apparently low cost of borrowing from abroad". They note that the rate has also been used in evaluating some projects by the government.

We value land for the cattle dip site arbitrarily at Shs. 20,000. Retaining the assumptions we made in the previous analysis on mortality and increase in milk production, spontaneous use of AI by all farmers and a project life of ten years, we estimate the following discounted benefits and costs of tick control.

	Shs.
Increase in milk production from Zebu cattle.	143.50
Alleviated cattle mortality	515.80
Improvement of cattle	210.10
TOTAL	869.40
Construction and maintenance of a cattle dip plus the supporting AI and other services	177.40
Private spraying plus supporting services	374.30

From these results, the benefits have increased tremendously, mainly as a result of a higher valuation of beef and a lower rate of discount for the society than per individual farmers. On the other hand, there is no major change in the final results for the costs of control, except for the private spraying. From this tentative evidence, we conclude that tick control, under reasonable assumptions, is a socially viable investment in the high potential and tick-borne diseases endemic areas. As tick control is, apparently, more profitable to the society than for the individual farmers, this finding may be used as a further argument for some level of government subsidisation in tick-control provision.

FOOTNOTES

1. See, for example, Mbere SRDP Development Programme - Review/Replan 1973/74 - 1975/76.

However, the 1967 FAO Livestock Survey estimated 3000 animals per cattle dip in Tanzania.

2. See the experiment by C.J. van Velzen and J. Slagboom entitled "A study about the relation between the growth performance of calf, the age at first calving and the milk yield during the first lactation" in MOA National Animal Husbandry Research Station. Dairy Cattle Research Project, Naivasha. Part II, 1975.

3. In absense of readily available information of the relative quantities of meat of different qualities delivered to the KMC, we calculate a simple arithmetic mean of the following prices to get the mean price that we use in the analysis.

Grade	Price per Kg. in 1977
GAQ	7.47
FAQ	7.35
3rd	5.19
4th	4.54

Source: Statistical Abstract, 1978, p.108 table 88.

4. Hopcraft et al.(1976,p62)estimate the value of Zebu heifer and bull calves at only Shs.60 and Shs.40 respectively. We consider these estimates too conservative since we define calves to include animals just less than one year old. They value grade heifer and bull calves at Shs.630 and Shs.65 respectively under medium cattle husbandry standards.

5.

Province	No. of Holders Owning Cattle	Total No. of Cattle in 1974/75.	Number Per Landholding
Central	233.7	104.3	4.5
Coast	22.1	290.7	13.2
Eastern	238.2	1511.3	6.3
Nyanza	232.7	2158.2	9.3
R. Valley	76.3	1080.6	14.2
Western	146.9	751.4	5.1
	949	6835.4	7.2

Source: Adapted from the Statistical Abstract, 1978 p.140, table 123. Excludes pastoral and large-farm areas.

6. The ideal would have been the use of a computerized herd model, which would have allowed the testing of a wide range of assumptions and a longer time horizon.

7. Scheme Specific Costs of Kenya National Artificial Insemination Service.

	Total Cost of Scheme Shs.	Number of Inseminations	Cost per Insemination
Total Central Province	2,906,301.00	254,570	11.42
Total Eastern Province	926,842.20	58,368	15.88
Total Western Province	602,427.40	16,893	35.66
Total Rift Valley Province	2,278,793.45	149,446	15.25
Total Nyanza Province	375,754.75	10,844	34.65
Taita-Coast Province	108,115.75	2,844	38.02
National Average			14.60

CHAPTER SIX

SUMMARY AND CONCLUSIONS

In Chapter One, background information is presented on the nature of ticks and tick-borne diseases. Evidence is also presented to show that ticks and tick-borne diseases are a major impediment to the development of the livestock sector. They cause significant production losses through mortality, lowered productivity of the surviving animals and discouraged genetic improvement of cattle in the high potential areas. The last imposes a high opportunity cost, as genetically improved cattle have a productivity several times higher than that of the unimproved. The high potential areas have in the absence of tick control, the highest ECF challenge.

In Chapter Two, we analyse ticks and tick-borne diseases in a historical perspective and in the context of the Kenyan livestock economy. From the analysis, it is evident that a lot of resources have been invested in tick control over time, both by the farmers and the government,and without much success in containing the losses from the diseases, particularly ECF, in the smallholder and pastoral areas. A major problem has been in the operation of the communal cattle cattle dips and spray-races, which are the most economical (on a cost-efficiency basis) to smallholders and pastoralists. Mainly because of this problem, the government, in 1976, initiated the Cattle Tick Control Project to improve control in the smallholder and some pastoral areas -

by taking over the purchase and distribution of acaricides and the overall management of the cattle dips.

With the livestock sector contributing about 27% to the marketed agricultural production, and dominated by smallholders and pastoralists, there is a wide potential for raising employment, incomes and improving income distribution through diseases control. In this regard, tick-borne diseases should be considered alongside other diseases that confront the livestock sector (e.g. FMD and C.B.P.P) and other supporting services such as AI, pasture improvement and the marketing and pricing policies.

To explain the fairly limited success of ticks and tick -borne diseases control in smallholder and pastoral areas, Chapter Three notes that an economic problem exists in the farmer allocation of resources to tick control. Various factors factors cause a divergence between the social and private benefits from their control. These factors include significant externalities, risk, economies of scale and indivisibility of tick control facilities, and farmer ignorance. Government involvement was found essential to induce a more optimal allocation of resources to tick control. Major factors to consider include the provision, distribution and operation of dips and spray races. Where there are significant externalities (with a large proportion of genetically unimproved cattle) direct charges for the use of communal tick control facilities should be nominal or zero. Instead, their operation should be financed through general taxation and/or lumpsum taxes on the livestock economy which have no resource allocative impact. Empirical evidence showing that dipping fees affect resource allocation to tick control where there are large spread externalities is presented in the chapter. The introduction of markets for risk (insurance) was found not feasible in view of the complexity of other problems that confront the livestock sector.

In Chapter Four, econometric analysis is undertaken to justify the economic policy issues raised in Chapter Three. The impact of the ECF risk on the cattle breed portfolio, and the latter's impact on farmer participation in tick control are analysed. The analysis is undertaken in a wider context, and incorporate availability of cattle dips and spray races in different districts and the land potential and tenure systems. The analysis is successful in explaining the interdistrict variation in cattle breed portfolio and farmer participation in tick control. The ECF challenge, expectedly, imposes a negative influence on cattle improvement. Its significance is however, overshadowed by the availability of tick control facilities. This is consistent with a general observation that increase in cattle dips and the dipping rate in some areas often lead to an upsurge in the grade cattle population, as risk from ECF and other tick-borne diseases is reduced. Improved cattle, in the analysis, induce a higher farmer participation in tick control. A communal land tenure system imposes a negative influence both on the farmer incentive to genetically improve cattle, and to participate in tick control.

In Chapter Five, we find that in a cost-benefit framework, tick control is a viable investment to farmers and society. The magnitude of benefits, however, and consistent with the previous analysis, depend crucially on the level of cattle improvement adopted. The net benefits are only marginal when no genetic improvement is postulated and become negative if the farmers use private spraying - which is a more expensive method of control.

The overall conclusion one draws from this preliminary study is that economic factors play a significant role in the farmers' decisions on the allocation of resources to tick control. They should be taken into account in the design of a feasible tick control policy.

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TABLE A.1: APPRAISAL OF BENEFITS AND COSTS OF TICK CONTROL. 2000 CATTLE MODEL HERD PROJECTIONS WITHOUT EFFECTIVE TICK CONTROL AND WITH SPONTANEOUS ADOPTION OF AI.

Zebu Cattle	Initial Numbers and applied rates	YEAR 1	2	3	4	5	6	7	8	9	10
Female Calves											
Mortality											
Total	164										
Heifers 1 - 2 years	165	164									
Heifers 2 - 3 years		165	164								
Sales		(32)	(31)								
Total		133	133								
Cows											
Initial herd		722	754	754	754	641	545	463	394	335	285
Additions		+165	+133	+133							
Total		887	887	887							
Sales	15%	(133)	(133)	(133)	(113)	(96)	(82)	(69)	(59)	(50)	(43)
Total	722	754	754	754	641	545	463	394	335	285	242
Male Calves											
Mortality											
Total	164										
Steers and Bulls											
Initial herd		619	(317)	0							
Additions		+164									
Total		783									
Sales[b]		(466)	(317)	(0)							
TOTAL	619	317	0	0							
TOTAL HERD	2000[c]	1368	887	754	641	545	463	394	335	285	242

Continued ....

*Notes to this section are on page A(xvii)

Table A.11. cont'd

Improved Cattle	Initial Cattle numbers and rates applied	1	2	3	4	5	6	7	8	9	10
Female Calves											
From Zebu Cattle		220	230	230	230	195	166	141	120	102	87
From grade cattle					+26	+44	+56	+66	+71	+72	+71
Total					256	239	222	207	191	174	158
Mortality	28%[d]	(62)	(64)	(64)	(72)	(67)	(62)	(58)	(53)	(49)	(44)
Total		158	166	166	184	172	160	149	138	125	114
Heifers 1 - 2 years[e]			158	166	166	184	172	160	149	138	125
Mortality	28%[d]		(44)	(46)	(46)	(51)	(48)	(45)	(42)	(39)	(35)
Total			114	120	120	133	124	115	107	99	90
Cows > 2 years					74	126	159	189	202	205	202
Additions				+114	+120	+120	+133	+124	+115	+107	+ 99
Total					194	246	292	313	317	312	301
Mortality	28%[d]			(32)	(54)	(69)	(82)	(88)	(89)	(87)	(84)
Total				82	140	177	210	225	228	225	217
Sales	10%[c]			(8)	(14)	(18)	(21)	(23)	(23)	(23)	(22)
TOTAL				74	126	159	189	202	205	202	195
Male Calves : From Zebu Cattle		220	230	230	230	195	166	141	120	102	87
From Grade Cattle					+26	+44	+56	+66	+71	+72	+71
TOTAL					156	239	222	207	191	174	158

Continued ......

Improved Cattle	Initial Cattle numbers and rates applied	1	2	3	4	5	6	7	8	9	10
Mortality	28%	(62)	(64)	(64)	(72)	(67)	(62)	(58)	(53)	(49)	(44)
Total		158	166	166	184	172	160	149	138	125	114
Sales[b]				(51)	$65)	(41)	(20)	(12)	(9)	(0)	(0)
Total				115	119	131	140	137	129	125	289
Bulls and Steers				111	148	124	113	156	200	254	276
Additions			+158	+166	+115	+119	+131	+140	+137	+129	+125
Total				277	263	243	244	296	337	383	401
Mortality	28%		(44)	(78)	(74)	(68)	(68)	(83)	(74)	(107)	(112)
Total			114	199	189	175	176	213	263	276	289
Sales[b]			(3)	(51)	(65)	(42)	(20)	(13)	(9)	(0)	(0)
Total			111	148	124	133	156	200	254	276	289
TOTAL HERD		316	557	623	673	728	769	803	833	827	802

TABLE A.2: 2000 CATTLE MODEL HERD PROJECTIONS WITH EFFECTIVE TICK CONTROL AND SPONTANEOUS ADOPTION OF AI

Improved Cattle		YEAR 1	2	3	4	5	6	7	8	9	10
Zebu Herd Calving Rate (CI)	61%	62%	64%	65%	65%	65%	65%	65%	65%	65%	65%
Cattle Mortality Following	28%	20%	10%	5%	5%	5%		5%	5%	5%	5%
Female Calves											
From Zebu cattle		220	234	241	245	208	177	150	128	109	93
From Grade Cattle					+47	+62	+73	+101	+119	+130	+132
Total					292	270	250	251	247	239	225
Mortality		(44)	(23)	(12)	(15)	(14)	(13)	(13)	(12)	(12)	(11)
Total		176	211	229	277	256	237	238	235	227	214
Heifers 1 - 2 Years			176	211	229	277	256	237	238	235	227
Mortality			(18)	(11)	(11)	(14)	(13)	(12)	(12)	(12)	(11)
Total			158	200	218	263	243	225	226	223	216
Cows > 2 Years					135	178	209	289	340	372	377
Additions				+158	+200	+218	+263	+243	+225	+226	+223
Total					335	396	472	532	565	598	600
Mortality				(8)	(17)	(20)	(24)	(27)	(28)	(30)	(30)
Total				150	318	376	448	505	537	568	570
Sales[a]	10%			(15)	(32)	(38)	(45)	(51)	(54)	(57)	(57)
Additional Sales[b]					(108)	(129)	(114)	(114)	(111)	(134)	(141)
Total				135	178	209	289	340	372	377	372

Continued ......

TABLE A.2: Cont'd

Improved Cattle		1	2	3	4	5	6	7	8	9	10
Zebu Herd Calving Rate	61%	62%	64%	65%	65%	65%	65%	65%	65%	65%	65%
Cattle Mortality Following	28%	20%	10%	5%	5%	5%	5%	5%	5%	5%	5%
Male Calves : From Zebu Cattle		220	234	241	245	208	177	150	128	109	93
From grade cattle					+47	+62	+73	+101	+119	+130	+132
Total					292	270	250	251	247	239	225
Mortality		(44)	(23)	(12)	(15)	(14)	(13)	(13)	(12)	(12)	(11)
Total		176	211	229	277	256	237	238	235	227	214
Sales[b]		(36)	(75)	(175)	(277)	(256)	(237)	(238)	(255)	(227)	(244)
Total		140	136	54	0	0	0	0	0	0	0
Bulls and Steers				52	5						
Additions			140	+136	+54						
Total				188	59						
Mortality			(14)	(9)	(3)						
Total			126	179	56						
Sales[b]			(74)	(174)	(56)						
Total			52	5	0						
TOTAL GRADE HERD	0	316	557	623	673	728	769	803	833	827	802

ADOPTION OF AI.

Zebu Cattle	Initial herd and applied Rates	YEAR 1	2	3	4	5	6	7	8	9	10
Assumed progress in use of AI	10%	25%	40%	55%	70%	85%	100%				
Female Calves		198	173	138	103	69	34				
Mortality	30%[d]	(59)	(52)	(41)	(31)	(21)	(10)				
Total		139	121	97	72	48	24				
Heifers 1 - 2 years											
Total		164	139	121	97	72	48	24			
Heifers 2 - 3 years		165	164	139	121	97	72	48	24		
Sales		(32)	(31)	(6)	(0)	(0)	(0)	(0)	(0)		
Total		133	133	133	121	97	72	48	24		
Cows											
Initial herd		722	754	754	754	754	744	715	669	609	
Additions		+165	+133	+133	+133	+121	+97	+72	+48	+24	
Total		887	887	887	887	875	841	787	717	633	536
Sales[a]	15%	(133)	(133)	(133)	(133)	(131)	(126)	(118)	(108)	(95)	(81)
TOTAL		754	754	754	754	744	715	669	609	538	455
Male Calves		198	173	138	103	69	34				
Mortality	30%[d]	(59)	(52)	(41)	(31)	(21)	(10)				
Total		139	121	97	72	48	24				

Continued ......

TABLE A. 3: Cont'd

Zebu Cattle	Initial herd and applied Rates	YEAR 1	2	3	4	5	6	7	8	9	10
Assumed progress in use of AI	10%	25%	40%	55%	70%	85%	100%				
Steers and Bulls											
Initial herd		619	607	516	380	196	43	41			
Additions		+164	+139	+121	+97	+72	+48	+24			
Total		783	746	637	477	268	91	65			
Sales[b]		(176)	(230)	(257)	(281)	(225)	(50)	(65)			
Total		607	516	380	196	43	41	0			
TOTAL ZEBU HERD	2000[c]	1936	1784	1582	1312	1052	924	741	633	538	455

Continued ....

YEAR.

Improved Cattle		1	2	3	4	5	6	7	8	9	10
Female Calves											
From Zebu Cattle		22	58	92	126	161	193	218	204	185	164
From Grade Cattle					+3	+ 8	+19	+27	38	49	61
Total					129	169	212	245	242	234	225
Mortality	28%	(6)	(16)	(26)	(36)	(47)	(59)	(67)	(68)	(66)	(63)
Total		16	42	66	93	122	153	178	174	168	162
Heifers 1 - 2 years[e]			16	42	66	93	122	153	178	174	168
Mortality	28%[d]		(4)	(12)	(18)	(26)	(34)	(43)	(50)	(49)	(47)
Total			12	30	48	67	88	110	128	125	121
Cows > 2 years					8	24	53	77	108	141	174
Additions				+12	+30	+48	+67	+88	+110	+128	+125
Total				12	38	72	120	165	218	269	299
Mortality	28%[d]			(3)	(11)	(23)	(34)	(45)	(61)	(75)	(84)
Total				9	27	59	86	120	157	194	215
Sales[a]	10%			(1)	(3)	(6)	(9)	(12)	(16)	(20)	(22)
Total				8	24	53	77	108	141	174	193
Male Calves: From Zebu Cattle		22	58	92	126	161	193	218	204	185	164
From grade cattle					+3	+8	+19	+27	+38	+49	+61
Total[d]					129	169	212	245	242	234	225

Continued .....

TABLE A[illegible]. Cont'd

		1	2	3	4	5	6	7	8	9	10
Mortality	28%[d]	(6)	(16)	(26)	(36)	(47)	(59)	(67)	(68)	(66)	(63)
Total		16	42	66	93	122	153	178	174	168	162
Sales[b]						(6)	(50)	(51)	(51)	(39)	(27)
Total						116	103	127	123	129	135
Bulls and Steers				12	39	76	116	117	107	118	135
Additions			+16	+42	+66	+93	+116	+103	+127	+123	+129
Total				54	105	169	232	220	234	241	264
Mortality	28%[d]		(4)	(15)	(29)	(47)	(65)	(62)	(66)	(67)	(74)
Total			12	39	76	122	167	158	168	174	190
Sales[b]			(0)			(6)	(50)	(51)	(50)	(39)	(28)
Total			12			116	117	107	118	135	162
TOTAL GRADE HERD		32	108	209	344	474	538	630	684	731	773

TABLE A4 : 2000 CATTLE MODEL HERD PROJECTIONS WITH EFFECTIVE TICK CONTROL AND GRADUAL ADOPTION OF AI

		YEAR									
Zebu		1	2	3	4	5	6	7	8	9	10
Calving rate	61%	62%	64%	65%	65%	65%	65%	65%	65%	65%	65%
Assumed Progress in use of AI	10%	25%	40%	55%	70%	85%	100%	100%	100%	100%	100%
Calf mortality from	30%	20%	10%	5%	5%	5%	5%	5%	5%	5%	5%
Female Calves		198	175	145	110	74	37				
Mortality		(40)	(18)	(7)	(6)	(4)	(2)				
Total		158	157	138	104	70	35				
Heifers 1-2 years Total		164	158	157	138	104	70	35			
Heifers 2-3 years		165	164	158	157	138	104	70	35		
Sales		(32)	(31)	(25)	(24)	(104)	(0)	(22)	(2)		
Total		133	133	133	133	34	104	48	33		
Cows											
Initial herd		722	754	754	754	754	754	670	658	600	538
Additions		+165	+133	+133	+133	+133	+34	+104	+48	+33	
Total		887	887	887	887	887	788	774	706	633	
Sales[a]	15%	(133)	(133)	(133)	(133)	(133)	(118)	(116)	(106)	(95)	(81)
Total		754	754	754	754	754	670	658	600	538	457
Male Calves		198	175	145	110	74	37				
Mortality		(40)	(18)	(7)	(6)	(4)	(2)				
Total		158	157	138	104	70	35				

Continued ......

TABLE A4 : Cont'd

Zebu		I	2	3	4	5	6	7	8	9	10
Steers and Bulls											
Initial herd		619	569	425	262	79	70	10			
Additions		+164	+158	+157	+138	+104	+20	+35			
Total		783	727	582	400	183	90	45			
Sales[b]		(214)	(302)	(320)	(321)	(163)	(80)	(45)			
Total		569	425	262	79	20	10	0			
Total Zebu Herd	2000[c]	1936	1784	1582	1312	1052	924	741	633	538	457

Continued ....

Grade Cattle		1	2	3	4	5	6	7	8	9	10
Mortality Rate	28%	20%	10%	5%	5%	5%	5%	5%	5%	5%	5%
Calving Rate	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
Female Calves											
From Zebu		22	58	97	135	172	208	218	214	195	175
From Grade					+5	+19	+42	+45	+54	+67	84
Total					140	191	250	263	268	262	259
Mortality		(4)	(6)	(5)	(7)	(10)	(13)	(13)	(13)	(13)	(13)
Total		18	52	92	133	181	237	250	255	249	246
Heifers 1 - 2 years[e]			18	52	92	133	181	237	250	255	249
Mortality			(2)	(3)	(5)	(7)	(12)	(13)	(13)	(13)	(12)
Total			16	49	87	126	172	225	237	242	237
Cows > 2 years					13	53	120	129	155	192	240
Additions				+16	+49	+87	+126	+172	+225	+237	+242
Total					62	140	246	301	380	429	482
Mortality				(1)	(3)	(7)	(12)	(15)	(19)	(21)	(24)
Total				15	59	133	234	286	361	408	458
Sales[a]	10%			(2)	(6)	(13)	(23)	(29)	(36)	(41)	(46)
Additional Sales[b]							(82)	(102)	(133)	(127)	(122)
Total				13	53	120	129	155	192	240	290
Male Calves: From Zebu		22	58	97	135	172	208	218	214	195	175
From Grade					+5	+19	+42	+45	+54	+67	+84
Total					140	191	250	263	268	262	259

Continued..........

Cont'd

	1	2	3	4	5	6	7	8	9	10
Mortality	(4)	(6)	(5)	(7)	(10)	(13)	(13)	(13)	(13)	(13)
Total	18	52	92	133	181	237	250	255	249	246
Sales[b]	(4)	(12)	(37)	(62)	(134)	(237)	(250)	(255)	(249)	246
Total	14	40	55	71	47	0	0	0	0	0
Bulls and Steers										
Additions		14	40	55	71	47				
Total										
Mortality		(1)	(2)	(3)	(4)					
Total		13	38	52	67					
Sales		(13)	(38)	(52)	(67)	(47)				
Total		0	0	0	0	0	0	0	0	0
Total Herd(Grade)	32	108	209	344	474	538	630	684	731	773

TABLE: A.5: <u>2000-CATTLE MODEL HERD PROJECTIONS WITHOUT AI AND TICK CONTROL</u>

Zebu Cattle	Initial numbers and applied rates	YEAR 1	2	4	4	5-20
Female Calves		220	230	230	230	230
Mortality	30%[d]	(66)	(69)	(69)	(69)	((69)
Total	164	154	161	161	161	161
Heifers 1-2 years						
Total	165	164	154	161	161	161
Heifers 2-3 years		165	164	154	161	161
Sales		(32)	(31)	(21)	(28)	(28)
Total	165	133	133	133	133	133
Cows						
Initial herd		722	754	754	754	754
Additions		+165	+133	+133	+133	+133
Total		887	887	887	887	887
Sales[a]	15%	(133)	(133)	(133)	(133)	(133)
Total	722	754	754	754	754	754
Male Calves		220	230	230	230	230
Mortality	30%[d]	(66)	(69)	(69)	(69)	(69)
Total	164	154	161	161	161	161
Steers and bulls						
Initial herd		619	619	619	619	619
Additions		+164	+154	+161	+161	+161
Total		783	773	780	780	780
Sales[b]		(122)	(136)	(150	(150)	(150)
Total	619	661	637	630	630	630
Total Zebu Herd	2000[c]	2000	2000	2000	2000	2000

TABLE A.6: 2000 CATTLE MODEL HERD PROJECTIONS WITH EFFECTIVE TICK CONTROL BUT [illegible]

Zebu Cattle		1	2	3	4	5	6	7 - 10
Calf Mortality	30%	20%	10%	5%	5%	5%	5%	5%
Calving Ratio	61%	62%	64%	65%	65%	65%	665%	65%
Female Calves		220	234	241	245	245	245	245
Mortality		(44)	(23)	(12)	(12)	(12)	(12)	(12)
Total		176	211	229	233	233	233	233
Heifer 1 - 2 yrs								
Total		164	176	211	229	233	233	233
Heifers 2 - 3 years		165	164	176	211	229	233	233
Sales		(32)	(31)	(43)	(78)	(96)	(100)	(100)
Total		133	133	133	133	133	133	133
Cows								
Initial herd		722	754	754	754	754	754	754
Additions		+165	+133	+133	+133	+133	+133	+133
Total		887	887	887	887	887	887	887
Sales[a]	15%	(133)	(133)	(133)	(133)	(133)	(133)	(133)
Total		754	754	754	754	754	754	754
Male Calves		220	234	241	245	245	245	245
Mortality		(44)	(23)	(12)	(12)	(12)	(12)	(12)
Total		176	211	229	233	233	233	233

Continued ....

Zebu Cattle		1	2	3	4	5	6	7 - 10
Calf Mortality	30%	20%	10%	5%	5%	5%	5%	5%
Calving Ratio	61%	62%	64%	65%	65%	65%	65%	65%
Steers and Bulls								
Initial herd		619	597	515	444	418	414	414
Additions		+164	+176	+211	+229	+233	233	233
Total		783	773	726	673	651	647	647
Sales[b]		(186)	(258)	(282)	(255)	(237)	(233)	(233)
Total		597	515	444	418	414	414	414
Total Zebu Herd	2000[c]	2000	2000	2000	2000	2000	2000	2000

NOTES:

a. Assume that 15% of the indigenous cows are culled because of calving problems and infertility. We assume a 10% rate for the improved cattle.

b. Sales are undertaken in such as a way as to maintain the desired herd size. We start with a 2000-herd model with each improved animal substituting 2 genetically unimproved animals. This is to allow for the fact that farmers allocate more land and management resources to improved cattle.

c. The initial Zebu herd composition reflects the results of the 1974/75 Integrated Rural Survey on the composition of unimproved cattle in smallholder agricultural areas. See the 1978 Statistical Abstract, p.141.

d. From the evidence presented in the Chapter, we apply a calf mortality rate of 30% in a tick-borne diseases endemic area for the unimproved cattle. A mortality rate of 28% for all ages of improved cattle is applied where tick control is not effecient and effective. The rates are reduced to 5% (with some time lag) following effecient tick control.

e. The only one category of heifers for improved cattle is to allow for the fact that they have a lower calving age.

TABLE A.7

EFFECTIVE TICK CONTROL AND SPONTANEOUS USE OF ARTIFICIAL INSEMINATION: COMPUTATION OF BENEFITS AND COSTS OF EFFECTIVE TICK CONTROL

YEAR.

	0	1	2	3	4	5	6	7	8	9	10
1. Improvement of Cattle. No. of grade cattle in milk					94	124	146	202	238	264	
Increase in milk output at 544 Litres[1] per animal and Shs. 1.19 per litre					60851.84	80272.64	94514.56	130 776.74	15407168	16831360	170903
Discount factor at 15%	1.000	.8696	.7561	.6575	.5718	.4972	.4323	.3759	.3269	.2843	.2472
Present value (PV) of the benefits					34795.08	39911.56	40858.64	49155.23	50366.03	47851.56	42247.2
Total PV	305185.33										
Average per animal in the initial herd	152.59										
2. No. of Zebu cattle in milk		440	460	460	460	195	166	141	120	102	87
Increase in milk output @ 108.8L[2]. per animal and Shs.1.19 per L.		56967.68	59557.12	59557.12	59557.12	25247.04	21492.35	18255.55	15536.64	13206.14	11264.0(

*Notes to this section are on page A(xxviii)

Continued ......

TABLE A.7: Cont'd

	0	1	2	3	4	5	6	7	8	9	10
Present Value @ 15%	208,107.75	49539.09	45031.14	39158.81	34054.76	12552.83	9291.14	6862.26	5078.93	3754.51	2784.48
Average per animal in the initial 2000-cattle herd	104.05										
Increase in milking cows from a higher calving rate following tick control		0	8	22	30	26	22	18	16	14	12
Milk output @ 380.8L[3] X Shs. 1.19		0	3625.22	9969.34	13594.56	11781.95	9969.34	6854.4	7250.43	6344	5437.82
Total Present Value @ 15%	35,331.55										
Average per animal in the initial herd	17.67										
3. Alleviated mortality losses											
No. of grade calves		36	82	104	114	106	98	90	82	74	66
No. of mature animals			56	128	143	154	161	177	165	191	190
Value @ Shs.400 per Calf and Shs.1000 per mature animal		14400	88,800	169600	188600	196400	200200	213000	197800	220600	216400
Total Present Value @ 15%	744151.30										

Average per animal in the initial herd 372.10

Continued ....

YEAR

Costs of Effective tick Control With Spontaneous Use of AI	0	1	2	3	4	5	6	7	8	9	10
1. Dipping Fees Herd Size: Zebu	2000	1368	887	754	641	545	463	394	335	285	242
Total Grade	0	316	557	623	673	728	769	803	833	827	802
Total	2000	1684	1444	1377	1314	1273	1232	1197	1168	1112	1044
Dipping fees @ 20cts per dipping per week (Total Shs.10.40 p.a)	20800	17513.60	15017.60	14320.8	13665.60	13239.2	12812.8	12448.8	12147.2	11564.8	10657.6
Discount Factor at 15%	1.000	0.8696	0.7561	0.6575	0.5718	0.4972	0.4323	0.3759	0.3269	0.2843	0.2472
Present Value (PV)	20800	15229.83	11354.31	9415.93	7813.99	6592.52	5538	4679.50	3970.92	3287.87	2684.00
Total PV	91358.35										
Mustering Labour..400 herdsmen engaged for 1/3 man-day per week at an average wage of Shs.6.75 per man-day	46800	46800	46800	46800	46800	46800	46800	46800	46800	46800	46800
PV @ 15%	281679.84										
Overall dipping expenses	373,038.19										
Average per animal in the initial herd	186.52										
2. Construction and Maintenance of a cattle Dip Capital Costs	25,000										
Salvage Value. 20% recovered											(5000)
Dip attendant of Shs. 315 p.m.		3780	3780	3780	3780	3780	3780	3780	3780	3780	3780
Acaricides @ Shs.9.88 per animal		16637.92	14266.72	13604.76	12982.32	12577.24	12172.18	11826.36	11539.84	10986.56	1031472

Continued....

	YEAR										
	0	1	2	3	4	5	6	7	8	9	10
Mustering Labour (as for (1))		46800	46800	46800	46800	46800	46800	46800	46800	46800	46800
Total Cash Outflow	25,000	67217.92	64846.72	64184.76	63562.32	63157.24	62752.18	62406.36	62119.84	61569.56	55894.72
Present Value @ 15%	25,000	58452.7	49030.60	42201.48	36344.93	31401.78	27127.77	23458.55	20306.98	17503.37	13817.17
Total PV	344645.32										
Average per animal in initial herd	172.32										
3. Private Spraying											
Spraying Labour (Assumed same as for mustering Labour)		46800	46800	46800	46800	46800	46800	46800	46800	46800	46800
Hand-spray and bucket Shs.276x400	110,400										
Acaricides @ Shs.1.10 per animal per spray per week ie. Shs.57.20 p.a.		96324.8	82596.8	79590.6	75160.8	72815.6	70470.4	68468.4	66809.6	63606.4	59716.8
Total Spraying Expenses	110,400	143124.8	129396.8	126390.6	121960.8	119615.6	117270.4	115268.4	113609.6	110406.4	106516.8
Total Present Value @ 15%	733893.8										
Average per animal in the initial herd	366.95										

TABLE A.8: SENSITIVITY ANALYSIS OF BENEFITS

A). Gradual Acceptance of AI (assume six years) Following Effective tick Control

1. Alleviated Mortality Losses	0	1	2	3	4	5	6	7	8	9	10
No. of grade calves		4	20	42	58	74	92	108	110	106	100
Mature cattle			5	24	47	68	112	123	145	157	169
Value of Shs.400 per calf and Shs.1000 for adult cattle	..	1600	13000	40800	70200	97600	148,800	166,200	189000	199400	209000
Discount factor at 15%	1.000	0.8696	0.7561	0.6575	0.5718	0.4972	0.4323	0.3759	.3269	.2843	.2472
Total Present Value	423652.9										
Average Value per animal in herd	211.83										
b). No. of Zebu Calves		38	68	68	50	34	16				
Value at Shs.221 per calf [4]		8398	15028	15028	11050	7514	4536				
Present value @ 15%	40129.44										
Average value per animal in the herd	20.06										
Overall Increase per animal in the initial herd Shs.	231.90										
2).No. of Zebu cattle in milk		440	460	460	460	460	454	436	408	371	328
Increase in milk output at 108.8L[2] X Shs.1.19 per litre		56967.68	59557.12	59557.12	59557.12	59557.12	58780.29	56449.79	52824.58	48034.11	42466.82
Total Present Value at 15%	285448.06										
Increase in number of cows in milk from a higher calving rate following tick control		0	7	23	30	30	36	0	20	19	15
Increase in milk output @ 380.8L[3] X Shs.1.19 per Litre		0	3172.06	10422.50	19420.8	19420.8	16313.47	0	9063.04	8609.89	6797.28
Total Present Value @ 15%	44155.11										
Overall Increase in milk output	329603.17										
Value per animal in initial herd	164.80										

Continued ....

	0	1	2	3	4	5	6	7	8	9	10
3). Improvement. No. of Grade cattle in milk					10	38	84	90	108	134	168
Increase in milk output @ 544L[1] X Shs.1.19 per litre					6473.6	24599.66	94378.24	58262.40	69914.90	86746.24	108756.48
Total present value at 15%	135,742.84										
Value per animal in the initial herd	67.90										

Continued ....

A(xxiii)

B). No./Genetic Improvement of Cattle at all Following Institution of Effective Tick Control

1). Alleviated Mortality Losses. No. of Zebu Calves		44	92	114	114	114	114	114	114	144
Value @ Shs.221[4] per Calf		9724	20332	25194	25194	25194	25194	25194	25194	25194
Total Present Value @ 15%	109,314.79									
Average per animal in initial herd	54.66									
2). No. of cows in milk		440	460	460	460	460	460	460	460	460
Increase in milk output @ 108.8L[2] X Shs1.19 per L.		56967.68	59557.12	59557.12	59557.12	59557.12	59557.12	59557.12	59557.12	59557.12
Total Present Value @ 15%	296653.49									
Increased numbers through a higher calving rate		0	8	22	30	30	30	30	30	30
Increase in milk output @ 380.8 L. X Shs.1.19 per Litre[3]		0	3625.22	9969.34	13594.56	13594.56	13594.56	13594.56	13594.56	1359466
Discount Factor @ 15%	1.000	0.8696	0.7561	0.6575	0.5718	0.4323	0.3759	0.3269	.2843	.2472
Present Value		0	2741.03	6554.84	7773.37	6759.22	5876.93	5110.20	4444.06	3360.58
Total Present Value	46485.16									
Overall Increase	343138.65									
Average per animal in the initial herd	171.57									

TABLE A.9: SOCIAL COST-BENEFIT ANALYSIS: SPONTANEOUS USE OF AI AND EFFICIENT TICK CONTROL

	Adusting Factor	YEAR 0	1	2	3	4	5	6	7	8	9	10
1. Increase in milk output from improved cattle Shs.	1.000					60851.84	80272.64	94514.56	130,778.74	154071.68	168313.60	170903.04
Discount factor @ 10%		1.000	0.909	0.826	0.751	0.683	0.621	0.564	0.513	0.467	0.424	0.381
Present Value (PV)						41561.81	49849.31	53306.21.	67088.47	71951.47	71364.97	65114.06
Total PV		420236										
Average per animal in initial herd		210.12										
2. Increase in milk from the indigenous cattle	1.000		56967.68	59557.12	59557.12	59557.12	25247.04	21492.35	18255.55	15536.64	13206.14	11264.06
Present Value @10%			51783.62	49194.18	44727.40	40677.51	15678.41	12121.69	9365.10	7255.61	5599.40	4291.61
Total PV		240.694 53										
Average per animal in initial herd		120.35										
Increase in output from a high calving rate Shs.			0	3325.22	9969.34	13594.56	11781.95	9969.34	6854.4	7250.43	6344	5437.82
Present Value (PV) @ 10%				2994.43	9486.97	9285.08	73 16.59	5622.7	35 16.31	3385.95	2689.86	2071.81
Total PV		46389.7										
Average per animal in initial herd		23.18										
3. Alleviated Mortality loss from mproved cattle deaths	1.08^5		15552	95 904	183 168	203 688	212 112	216 216	230040	213 624	238 248	233 712
Present Value (PV) @ 10%			14 136 .77	79 216.7	137 559.16	139 118.9	131 721.55	121945.82	118010.51	99 762.4	101017.15	89044.27
Total PV		1031.533.2										
Average per animal in initial herd		515.80										
COSTS OF TICK CONTROL												
1). Construction and Maintenance of a cattle Dip.												

Continued ....

TABLE A.9: Cont'd

	Adjusting Factor	YEAR 0	1	2	3	4	5	6	7	8	9	10
Intial Construction expenses	0.80	20,000										
Salvage value												(4000)
Land		20,000										(20,000)
												(20,000)
Other Supporting Services shs 3 x Number of cattle			5052	4332	4131	3942	3813	3696	3591	3504	3336	3132
Dip Attendant	1.00		3780	3780	3780	3780	3780	3780	3780	3780	3780	3780
Acaricides	0.90		14974.13	12840.05	12244.28	11684.09	11131952	10954.86	10643.72	10385.86	9887.90	9283.25
Mustering Labour	0.50		23400	23400	23400	23400	23400	23400	23400	23400	23400	23400
No. of animals inseminated												
Zebu			440	468	482	490	221	188	159	136	116	[illegible]9
Grade						94	124	146	202	238	260	2[illegible]4
Cost of inseminations 2 x sh.14.60 per animal	0.79		10149.92	10795.82	11118.78	13471.71	7704.71	7704.71	8327.55	8627.43	8673.57	8373.68
cash flow		40000	57356.05	55147.87	54674.06	562778	50017.23	49535.67	49742.27	49697.29	49077.47	23968.93
Present value(PV) @ 10%		40000	52136.65	45552.14	41060.22	38437.74	31060.70	27938.12	25517.78	23208.63	20808.85	9132.16
Total		354852.88										
Average per animal in the initial herd		177.43										

Continued ....

TABLE A.9: Cont'd

	Adjusting Factor	YEAR 0	1	2	3	4	5	6	7	8	9	10
2).Spraying												
Labour			23400	23400	23400	23400	23400	23400	23400	23400	23400	23400
Handspray and bucket	0.90[6]		99,360									
Acaricides.	0.90		86692.23	74337.12	7163154	67644.72	65534.04	63423.36	61621.56	60128.64	57245.76	53745.12
Other supporting services			5052	4332	4131	3942	3813	3696	3591	3504	3336	3132
Cost of inseminations			10149.92	10795.82	11118.78	13471.71	7704.71	7704.71	8327.55	8627.43	8673.57	8373.68
Total Cost		99,360	125294.15	112864.94	11028 32	108458.43	100 451.75	98224.07	96940.11	95660.07	92655.33	88650.8
Present Value(PV) at 10%		99360	113892.36	93226.44	82821.27	74077.11	62380.54	55398.38	49730.28	44673.25	39285.86	33775.95
Total PV		748621.44										
Average Increase per animal in the initial herd		374.31										

1. From the assumption that improved cattle produce three times the Zebu cows output of 272 Litres in excess of calf needs. Therefore, the increase from upgrading Zebu cows is 544 litres per animal. The improved calf is assumped to feed on a proportionally higher volume of milk. Throughout, and for convenience, the lactation period is assumed to be one year. However, this understates the genetic improvement benefit because grade cows have longer **lactations.**

2. 20% increase to the output of Zebu cattle's output of 544 litres inclusive of the assumed calf milk needs. The amount taken by the calf is assumed constant.

3. The increase above added to the output of the Zebu cattle in excess of calf needs (i.e. 272 litres).

4. The assumed average weight of calves (36 Kg) X Shs.6.14 per Kg of the liveweight beef prices.

5. The arithmetic mean of the accounting ratios for beef and milk.

6. Apply the accounting ratio for metal products, as computed by Scott et al (1976).