African Union
InterAfrican Bureau for Animal Resources

Socio-economic Benefits of Rinderpest Eradication from Ethiopia and Kenya

Consultancy Report

By

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Acknowledgments

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Acronyms and Abbreviations

ARIS	Animal Resources Information System
ASALs	arid and semi-arid lands
AU-IBAR	African Union-InterAfrican Bureau for Animal Resources
CAPE	Community-based Animal Health and Participatory Epidemiology
CBAHW	Community-Based Animal Health Worker
CBPP	contagious bovine pleuropneumonia
CCPP	contagious caprine pleuropneumonia
DDCC	District Disease Control Committees
DVO	District Veterinary Officer
DVS	Director/Department of Veterinary Services
ECU	European currency unit
EIAR	Ethiopian Institute of Agricultural Research
EPERK	Emergency Programme for Eradication of Rinderpest in Kenya
FAO	Food and Agriculture Organization of the United Nations
FMD	Foot and Mouth Disease
GDP	Gross Domestic Product
GREP	Global Rinderpest Eradication Program
HPAI	Highly Pathogenic Avian Influenza
ILRI	International Livestock Research Institute
JP15	Joint Project 15
KLIFT	Kenya Livestock Finance Trust
KVA	Kenya Veterinary Association
MOARD	Ministry of Agriculture and Rural Development
OAU	Organization of African Unity
OIE	*Office International des Épizooties*
PACE	Pan African Program for the Control of Epizootics
PANVAC	Pan African Veterinary Vaccine Centre
PARC	Pan-African Rinderpest Campaign
PDVS	Provincial Director of Veterinary Services
PPR	*Peste des Petits Ruminants*

RP	rinderpest
RVF	Rift Valley Fever
SAM	Social Accounting Matrix
SERECU	Somali Ecosystem Rinderpest Eradication Coordination Unit
SPS	Sanitary and Phytosanitary
SSA	sub-Saharan Africa
USA	United States of America
WTO	World Trade Organization

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Executive Summary

This study sought to evaluate the costs and benefits of rinderpest eradication from Ethiopia and Kenya. The study used primary data collected through interviews with key informants in Ethiopia and Kenya. Secondary data were also used. In particular, FAOSTAT (2010) cattle population data were used due to lack of consistent country level series covering the study period (1968-2008). Due to the aggregated nature of FAOSTAT data, it was imperative to make assumptions on the data to facilitate the computation of benefits of rinderpest eradication. As far as possible such assumptions were backed up by relevant literature. The costs and benefits of rinderpest eradication were evaluated under a social cost-benefit framework.

The study made the following key findings:

- The total benefits of rinderpest eradication from Ethiopia and Kenya were US$ 951.3 million and US$ 433.97 million respectively. In Ethiopia, the largest proportion of these benefits (65%) was contributed by PARC through gains from beef production. In Kenya, the largest proportion of the benefits (43.7%) came from PACE, mainly due to its effect on milk production.
- In both countries the NPVs were large and positive indicating that rinderpest eradication generated substantial returns to both economies.
- Likewise, the BCRs were also greater than unity suggesting that the money invested in rinderpest eradication in Ethiopia and Kenya was effectively used.
- On the other hand, Ethiopia's JP15, PARC and SERECU had IRRs that were comparatively higher than the current interest rate of 3% per annum on deposits offered by the Commercial Bank of Ethiopia. PACE-Ethiopia's IRR was only 2.6% suggesting that it did not yield sufficient returns to cover the cost of invested capital. In Kenya, the IRRs were fairly higher than the 7.4% return on the risk-free 91-day Treasury Bill offered by the Central Bank of Kenya in 2009. PARC and PACE had only marginal returns on investment of 11.9% and 8.6% respectively.
- Overall, rinderpest eradication contributed 2.4% and 0.5% to the Ethiopia's and Kenya's economies respectively. PARC-Ethiopia had the highest contribution (of 1.5%) to Ethiopia's economy while PACE-Kenya had the highest contribution (of 0.18%) to Kenya's economy.

- Rinderpest eradication expanded the final demand for livestock products in the rest of the economy. In Ethiopia, this amounted to US$ 457,594.8 while in Kenya the final demand expanded by US$ 231,379.3. Rinderpest eradication also increased the household incomes of livestock keepers in Ethiopia and Kenya by US$ 366,352.3 and US$ 2,822.8 respectively.
- The indirect benefits of rinderpest eradication include:
  - Capacity building, e.g., 10 veterinarians in Ethiopia were trained to MSc level courtesy of PARC-Ethiopia. Numerous other staff in Ethiopia and Kenya attended short-term training in various fields during the rinderpest eradication campaign.
  - Equipment of laboratories – many laboratories obtained materials and equipment during the rinderpest eradication campaign. However, none of the laboratories in Ethiopia and Kenya has international accreditation.
  - Disease surveillance methodologies e.g. participatory epidemiology and participatory disease search were developed and implemented in Ethiopia and Kenya during the rinderpest eradication campaigns. These methodologies are still being used for the surveillance of such diseases as FMD, CBPP, RVF, HPAI and PPR.
  - Elaborate communication networks have been established linking livestock keepers with the veterinary department. These networks are currently being used to report other diseases such as FMD, anthrax and CBPP. Since their creation, the networks have greatly enhanced disease reporting in both countries.
  - Although the privatization of veterinary services did not pick up in Ethiopia as envisaged under PARC, in Kenya, it saw the establishment of over 50 private veterinary clinics in high and medium agricultural potential areas. In the arid and semi-arid areas, the community-based animal health worker (CBAHW) model paved way for the privatization of animal health services in those areas.
  - According to the key informants from the farming community, the eradication of rinderpest from both Ethiopia and Kenya has led to improved food security because:
    - There no more rinderpest-related quarantines
    - Their animals are more healthy and therefore more productive

        - Their animals fetched better market prices that during the time of rinderpest outbreaks
        - Animals have more freedom to mix and to move across geographical areas in search of pasture and water.
    - Although rinderpest eradication has increased domestic trade in livestock and livestock products in Ethiopia and Kenya, external trade in livestock and livestock products in the two countries still remains unexploited largely due to the presence of other trans-boundary diseases (TADs) such as FMD and CBPP. These TADs still constrain livestock exports from the two countries.
    - AU-IBAR benefited from rinderpest eradication through
        - The fulfillment of its mandate (of eradicating rinderpest from Africa)
        - Capacity-building of human resources, facilities and equipment within AU-IBAR
        - Establishment of Epidemiology Units in various countries to coordinate disease surveillance and vaccination
        - Creation of a wide network and goodwill of governments, the private sector, civil society and donors that contributed toward the eradication of rinderpest from Africa. This network can be used as a platform for galvanizing support in future disease control/eradication initiatives
        - Lessons and knowledge acquired from rinderpest eradication which could be used in the control and/or eradication of other livestock diseases in future.

The following are the recommendations of the study:

1. Although rinderpest is eradicated, Africa should remain vigilant against possible future re-emergence of rinderpest. In this regard, all the rinderpest virus strains held in laboratories in Africa should either be destroyed or kept in high bio-security facilities to reduce the chances of the virus escaping. In the meantime, African states should put in place contingency plans to deal with possible future re-emergence of rinderpest.
2. Given that TADs are still rampant in Africa, there is need to establish an effective syndromic surveillance system for TADs. Such a system should link key stakeholders for the exchange

of disease information and for expeditious emergency response. The syndromic surveillance program should be mainstreamed in the AU-IBAR CAADP framework.

3. It is well known that many African countries are currently facing financial constraints due in part to the current global financial meltdown and partly due to rapidly growing human population. At the same time, donor funding has increasingly diminished in recent years. Therefore, African countries should come up with innovative ways to sustainably fund animal health services. A starting point would be to cut spending on non-growth promoting activities such as the military. Partnership with development partners should be maintained and strengthened. Additionally, trade expansion through regional economic integration could provide the much needed fiscal resources for disease control.
4. The African Union should strengthen its coordinating and advocacy roles. In particular, AU should lobby governments and the donor community to commit more financial resources for the development of livestock in Africa.

1. Introduction

1.1 Background

Rinderpest (German for "cattle plague"), is an acute and sometimes sub-acute highly infectious viral disease of cloven-hoofed mammals, both domesticated and wild. Cattle and the African buffalo (*Syncerus caffer*) are highly susceptible, while sheep and goats experience a subclinical or mild form of the disease (USAHA, 2008). Rinderpest is highly fatal, and can result in 90 percent mortality and 100 percent morbidity in susceptible animals, leading to massive loss of income and dietary proteins. In the mixed crop-livestock production systems, the disease reduces crop productivity due to its negative effects on manure and traction supply.

Rinderpest is mainly spread by direct contact with aerosolized virus and/or by ingestion of contaminated matter. The clinical signs include a high fever, red patches with discharge from around the eyes, nose and mouth; frothy saliva, constipation followed by diarrhoea, and death after a few days (USAHA, 2008). The disease has no known carrier state; infection results either in death or lifelong immunity (Mariner et al., 2005). In endemic areas where animals have developed immunity from exposure or vaccination, rinderpest is often a disease of young animals (CFSPH, 2008).

Historically, rinderpest is one of the oldest animal diseases known to man. It is believed to have originated from the Asian subcontinent from where it eventually spread to medieval Europe and Middle-East in the early 17th Century, principally through imports and military invasion. One of the earliest recorded irruptions of rinderpest into western Europe occurred in the 5th Century after the invasion of western Europe by the eastern European tribes[1]. By the turn of the 18th century, the disease is said to have killed some 200 million cattle in Europe alone (O'Toole, 2004).

In Africa, rinderpest appeared in Egypt in 1841 from the Mediterranean region (Tambi et al., 1999). The resulting epidemic killed 75 percent of cattle and buffaloes in Egypt. In Africa south of Sahara, the disease first appeared Ethiopia in 1884, again through cattle imports, but this time

[1]http://encyclopedia.jrank.org/RHY_RON/RINDERPEST_German_for_cattle_pl.html

from India. Between 1888 and 1889, the disease spread southwards, covering almost the entire Ethiopia as well as neighboring Somalia, Kenya, Sudan and Uganda. By the end of 1892, an estimated 90 percent of the cattle population in Ethiopia had been lost, while Uganda lost an estimated 95 percent its cattle population. The outbreak in Ethiopia triggered the Great Ethiopian Famine of 1888-1892, where millions of Ethiopians died of starvation (Spinage, 2003). By 1892, the disease had spread to West Africa and by 1897 reached South Africa where it burnt itself out in 1905. However, it flared up again in Kenya in 1907 (Figure 1). As it swept across Africa, rinderpest killed between 75 and 225 million head of African cattle by the end of the 19th century (O'Toole, 2004).

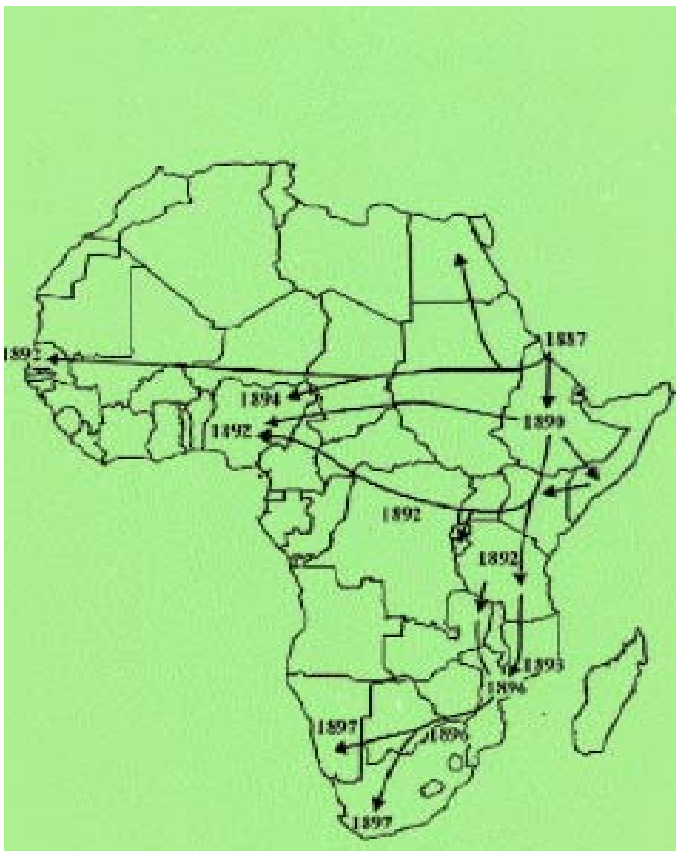

Figure 1. Spread of rinderpest in Africa from port Massawa, Ethiopia, in 1887
Source: http://www.taa.org.uk/rinderpest.pdf

Concerted efforts to eradicate rinderpest from Africa began in earnest in 1950 with the establishment of then Inter-African Bureau of Epizootic Diseases, currently the Inter-African

Bureau for Animal Resources (IBAR). The Bureau was charged with the responsibility of eliminating rinderpest from Africa. In this regard, the heads of African veterinary services meeting in Kano, Nigeria, in 1960 launched a multi-nation joint project (JP15) under the aegis of the then Organization of African Unity (OAU). The aim of JP15 was to vaccinate all cattle of all ages every year for three successive years. Twenty two countries participated in the JP15 of which 17 had rinderpest.

Phase I of JP15 was implemented in West and Central Africa from 1962 to 1965 and covered Nigeria, Niger, Cameroon and Chad. Phase II was extended westward to cover Benin, Ghana, Burkina Faso, Togo and parts of Mali and Côte d'Ivoire. Phase III of the project covered the remainder of Mali and the Ivory Coast, Chad, the Gambia, Guinea, Liberia, Mauritania and Sierra Leone from 1966 to 1969. Phase IV was implemented in East Africa covering Ethiopia, Kenya, Uganda, Sudan and Tanzania. The JP15 campaign cost an estimated US$16.4 million with US$7.2 million (44%) contributed by national governments, US$6.6 million (40%) by the European Development Fund (EDF) and US$2.6 million (16%) by the United States Agency for International Development (USAID) and the Governments of Great Britain, Germany and Canada (Tambi et al., 1999).

By the end of 1979, most of the participating countries were relatively free from rinderpest, except for a few sporadic outbreaks in Chad in 1970, Ethiopia in 1975 and Cameroon in 1976. This success gave great hope on the possibility of one day eradicating the disease from Africa. However, participating countries became complacent and did not see the need to continue vaccinating their animals in the absence of the disease. As a result, more than half of the countries reported increasing numbers of rinderpest outbreaks by mid 1980s.

The ensuing pandemic was so widespread that the African Heads of State meeting in Nairobi, Kenya, in 1981 pressed OAU to organize a fresh campaign. The Pan-African Rinderpest Campaign (PARC) was born and began operations in 1986 in 34 African countries with funding from the European Commission. PARC was part of the Global Rinderpest Eradication Program (GREP) coordinated by the then OAU-IBAR. Its main objective was "eradication of rinderpest in Africa with simultaneous vaccination campaigns in all countries with enzootic foci" (Spinage, 2003; p. 606). A subsidiary objective was to revitalize and develop veterinary services of member countries with a view to enabling them address other diseases for improved livestock production (Kariuki et al., 1999). PARC's main activities included mass vaccination, disease surveillance, restructuring of veterinary services and prevention of desertification in member countries. Immediate action began in 1986 in five countries where rinderpest had spread extensively; Burkina Faso, Ethiopia, Mali, Nigeria and the Sudan. Emergency activities then followed in 1987 in Togo, Kenya and Uganda. This first phase of PARC cost ECU 22.07 million. Phase II was implemented in Benin, Burkina Faso, Gabon, Ghana, Guinea-Bissau, Mali, Niger and Togo in West Africa and Tanzania and Uganda in East Africa at a cost of ECU 14.37 million. The third and final phase of PARC commenced in 1994/95 and ended in 1999. This phase was implemented in Burkina Faso, Cote d'Ivoire, Guinea-Bissau, Guinea, Mali, Mauritania, Niger, Central African Republic, Rwanda and Ethiopia to the tune of ECU 73.74 million.

PARC's main activities included mass vaccination, disease surveillance, restructuring of veterinary services and prevention of desertification in member countries. After 12 years of PARC, most Equatorial countries were largely free from rinderpest, and as of 1999, the region had declared provisionally free from rinderpest. However, two small foci in war-torn Sudan and Somalia persisted. The latter focus spilled over into Kenya and Tanzania, where rinderpest killed wildlife in the latter 1990s (Kock et al., 1999). These foci had not been cleared of rinderpest by the time PARC ended in 1999.

The evaluation of PARC in 1996 recommended the continuation of the program to galvanize the gains made and to facilitate the stumping out of rinderpest from remaining foci. This culminated in the formation of the Pan African Program for the Control of Epizootics (PACE) in 1998 with funding from the European Union[1]. Although PACE was initially intended to cover 32 African countries, only 30 actually implemented the program. PACE's main objectives were to consolidate the achievements of rinderpest eradication and to facilitate the control of major epizootic diseases. The ultimate goal was to contribute to poverty alleviation amongst livestock producers in Africa by improving animal productivity, trade and food security. The specific objectives were to (i) strengthen national and regional capacities to assess the technical and

[1]Pan-African Programme for the Control of Epizootics (PACE) Epidemiology Unit Final Report (1999-2007).

economic aspects of animal diseases and to generate appropriate programs for their control and (ii) safeguard animal health in Africa against principal epizootic diseases. PACE ran for five years between November 1999 and October 2004 at a cost of Euros 94.3 million.

The mid-term review of PACE in 2002 recommended its extension. Accordingly, the project was extended to February 2007. The specific objectives of the extension phase were to (i) sustain the uptake of networks for the surveillance of animal diseases, (ii) build capacity at AU-IBAR, (iii) eradicate rinderpest, and, (iv) strengthen the private sector in the delivery of services to livestock keepers.

By the time PACE wound up its activities in 2007, 27 African countries had made significant progress along the OIE pathway for the eradication of rinderpest. Of these, 16 had been recognized as "free from rinderpest", of which four were certified as "rinderpest free". In addition, the Somali Ecosystem Rinderpest Eradication Coordination Unit (SERECU) was established to coordinate efforts geared towards the final eradication of rinderpest from remaining foci in the Somali Ecosystem (south eastern Ethiopia, north eastern Kenya and Somalia). The first phase of SERECU ran from January 2006 to February 2007, with a bridging phase between March 2007 and April 2008. The second phase runs between May 2008 and June 2010. With a total budget outlay of Euro 4 million, the objective of SERECU is to dynamically manage a scientific, coordinated and time-bound regional program to ensure and verify freedom from rinderpest as well as achieve accreditation by OIE for countries in the Somali ecosystem.

This study endeavors to estimate the socio-economic benefits of eradicating rinderpest in Ethiopia and Kenya, the two countries in the suspected remaining rinderpest focus of the Somali Ecosystem.

1.2 Rinderpest eradication efforts in Ethiopia

1.2.1 Initial government efforts

As mentioned earlier, rinderpest was introduced in Ethiopia in 1887 by the invading Italian army. Since then subsequent Ethiopian governments made great efforts to control the disease. The earliest efforts were made by the Italian government which sent a veterinary mission to Ethiopia in 1889 to study the impact of rinderpest in the country. This led to the establishment of the first animal health diagnostic laboratory in Asmara in 1903. In 1907, Emperor Menelik II established a seven-ministry government, with the Ministry of Agriculture being dedicated exclusively to animal health mainly focusing on rinderpest control (MOARD, 2009). In 1945, the Ethiopian government started mass vaccination of cattle against rinderpest using vaccines developed at Gullele laboratory in Addis Ababa. By 1952, nine million cattle had been vaccinated against rinderpest. In spite of these initial efforts, rinderpest still persisted in Ethiopia.

1.2.2 JP15

In 1970, Ethiopia implemented the fourth phase of continental JP15. This phase was undertaken in the entire eastern Africa between 1968 and 1976 as part of the continent-wide effort to eradicate rinderpest. The earlier three phases of JP 15 were implemented in western and central Africa.

Prior to the first phase of JP1-Ethiopia, the Ethiopian government single-handedly implemented a pre-JP15 campaign between 1967 and 1970, to acquire experience on rinderpest eradication and to prevent a relapse of the disease in vaccinated areas. The Ethiopian JP15 proper (1970-1976) was implemented in four phases in 13 provinces except northern Ethiopia that was having civil unrest at the time (Table 1). Funding came mainly from the donor community.

Table 1. Phases of JP15 proper in Ethiopia

Phase	Period	Provinces
I	1970-1972	Sidamo & Bale
II	1971-1973	Shoa, Arusi (Arsi) & Hararghe
III	1972-1974	Gamo Gofa, Kefa Illubabor & Wollega
IV	1973-1976	Gojjam, Gonder, Wollo, Tigray & Eritrea[†]

Source: MOARD (2009)
[†]Eritrea was then part of Ethiopia

After the expiry of JP15 proper, a follow-up campaign was initiated in 1977 and lasted for three years up to 1979. The objective was to vaccinate the calf crops which had been born after the end of JP15 proper to reduce the risk of a rinderpest outbreak.

According to MOARD (2009), Ethiopia had an estimated 25 million cattle in 1970. JP15 proper intended to vaccinate 90% of this herd (or 22.5 million) annually for three years or 67.5 million cattle in total. In the end, JP15 managed to vaccinate a total of 59 million cattle, representing 78.7% of the total cattle population in three years. Consequently, rinderpest had not been eradicated by the end of JP15 proper. The pre- and post-JP15 proper vaccinated 7.2 and 30 million cattle, respectively (MOARD, 2009).

1.2.3 PARC

PARC in Ethiopia was implemented in three phases for 10 years between 1989 and 1999 (Table 2). In total, 57 million cattle were vaccinated, mainly during PARC I & II.

Table 2. Phases of PARC in Ethiopia

Phase	Period	Objectives	Strategy
I	1989-1991	- To re-establish control over rampant rinderpest situation	- Blanket vaccination of all Ethiopian cattle for two years starting from international borders inwards
II	1991-1994	- To control/eradicate rinderpest from Ethiopia	- Strategic blanket vaccination of cattle based on disease surveillance (sero-surveys & sero-monitoring)
III & extension	1994-1999	- To eradicate rinderpest from Ethiopia	- Rinderpest surveillance and rationally targeted vaccination of cattle in reservoir areas - Privatization of veterinary services, communication, training, forage development and livestock marketing

Source: MOARD (2009); Kariuki et al. (1999)

In 1995 there was a rinderpest outbreak in north Welo and south Tigray regions with morbidity of 950 cattle and a case fatality of 50% among animals of 1-3 years (Abraham et al., 1998, p. 269). The outbreak was quickly extinguished through emergency vaccination and intensive active surveillance thereafter. By 1999, following the successful containment of rinderpest and the absence of areas of unknown status, Ethiopia declared itself provisionally free from rinderpest on a zonal basis in May in accordance with the OIE pathway.

1.2.4 PACE

PACE Ethiopia took over from where PARC stopped in 1999. Its objective was to eradicate rinderpest from Ethiopia by sustaining the achievements of PARC. This was achieved through active surveillance in identified zones of the country, as well as along the borders with southern Sudan and south western Somalia. Through these efforts, Ethiopia ceased mass vaccination in March 2000. It is estimated that 3 million cattle[1] were vaccinated in six Woredas during the PACE project (MOARD, 2009). By the time PACE ended in 2004, only south eastern Ethiopia remained as the last possible focus for rinderpest in the world. Effective eradication of rinderpest from this focus has been hindered by inaccessibility and perpetual civil conflict in Somalia.

1.2.5 SERECU

SERECU Ethiopia was established in 2006 to coordinate the final eradication of rinderpest from south eastern Ethiopian bordering Somalia and Kenya. SERECU's activities are geared towards the total eradication of rinderpest from Ethiopia thereby contributing towards the achievement of GREP's goal of eradicating rinderpest from the face of the earth by 2010.

1.3 Rinderpest eradication efforts in Kenya

1.3.1 Initial government efforts

Kenya was controlling rinderpest by the time the continent-wide JP15 was extended to East Africa in the late 1960s. Notably, Waller (2004) reports that Maasai herders were deliberately exposing their newly vaccinated animals to infection in order to get permanent immunity following the rinderpest campaign in Kajiado in 1931 (p. 50). By 1934, the colonial veterinary office's most important goal was eradication of rinderpest in Kenya. By 1939, there were "proposals for the eradication of rinderpest from Kenya" (Waller, 2004; p. 78). It is part of these government efforts that the Kabete "O" live attenuated tissue culture vaccine was

[1] Due to lack of data on the number of vaccinations done during the PACE project, we assumed that each Woreda had 0.5 million cattle at the time of vaccination.

developed in the 1960s by Dr W. Plowright and his team in Muguga (World Animal Review, 1991). By the time JP15 was extended to East Africa in 1968, rinderpest in Kenya was largely already under control (Figure 2) through mass immunization using the Kabete attenuated vaccine (Waller, 2004).

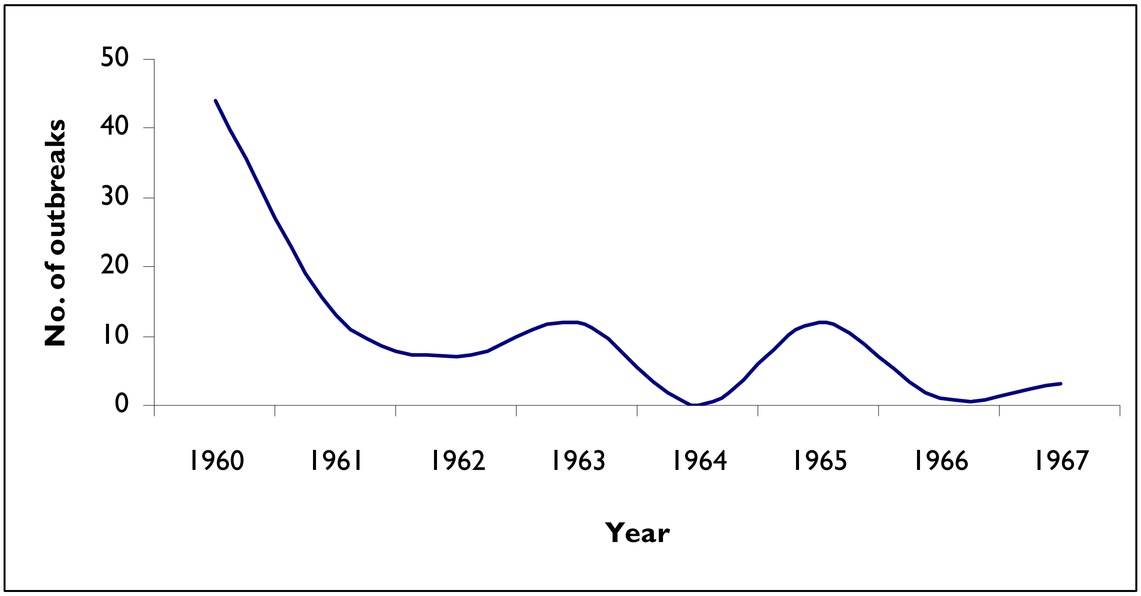

Figure 2. Trend of rinderpest outbreaks in Kenya (1960-1967)
Source: PACE Kenya Final Technical Report; Kariuki et al. (1999)

1.3.2 JP15

Kenya implemented its version of JP15 for three years between 1968 and 1971 at a cost of US$ 319,614[1]. Although the project was able to contain the disease, it was unable to eradicate it from Kenya and indeed in the majority of the countries where it was implemented. However, it produced important lessons key among which was the possibility of eradicating rinderpest from Africa. After the JP15, Kenya did not experience any rinderpest outbreak up to 1986 (Kariuki et al., 1999). In 1986, rinderpest re-emerged in West Pokot and Turkana Districts and outbreaks continued occurring albeit infrequently, through to 1996 when PARC was just being launched (Table 3).

[1]The exact cost of JP15-Kenya was not available. It was therefore assumed that Kenya used a third of the cost of JP15-Ethiopia, on the basis of cattle population.

Table 3. Number of rinderpest outbreaks after JP15

Year	1986	1987	1988	1989	1990	1991	1995	1996
Rinderpest outbreaks	1	1	3	1	1	1	2	3

Source: PACE Kenya Final Technical Report; Kariuki et al. (1999)

1.3.3 PARC

Prior to the implementation of PARC-Kenya, three rinderpest emergency campaigns were carried out in Kenya as shown in Table 4. These campaigns were more reactive and mainly implemented immediately after rinderpest incursions.

Table 4. Rinderpest emergency campaigns implemented in Kenya prior to PARC-Kenya

Emergency campaign	Year	Cost	Achievements
1st	1987	ECU 220,000	2.9 million cattle vaccinated along Kenya/Uganda border
2nd	1988/89	ECU 475,000	- 1.5 million cattle vaccinated in areas around Nairobi (Kiambu & Kajiado Districts) - support for regional laboratories to carry out AGID test & collect samples for serology
3rd	1996	ECU 95,000	- 732,330 cattle vaccinated around Tsavo & Nairobi National Parks - Investigations revealed rinderpest lineage II virus isolated in giraffe in 1930s.

Source: Kariuki et al. (1999)

PARC-proper was initially planned to start in 1988. However, its implementation was delayed by a decade due to certain "negotiation issues" with the main donor. PARC-Kenya was therefore implemented between February 1997 and 1999 with ECU 2.4 million[1] from the European Union and KShs 138,602,654 from the Government of Kenya (Kariuki et al., 1999). The program had five main components; (i) privatization of veterinary services, (ii) strengthening rinderpest control, (iii) strengthening CBPP control, (iv) strengthening FMD control and (v)

[1]This amount includes ECU 750,000 meant for a credit facility for the privatization of veterinarians in the Kenya Veterinary Association (KVA).

acaricide testing. Following disturbing patterns of rinderpest epidemiology in Kenya and its neighbors in 1996, Kenya simultaneously implemented the Emergency Programme for Eradication of Rinderpest in Kenya (EPERK) for one year[1]. The objective of the emergency program was to vaccinate 80% of the cattle population in the frontier Districts of the north and western Kenya to create a *cordon sanitarie* at the periphery to pave way for ring vaccination in case any rinderpest incursion occurred.

Between the expiry of JP15 in 1971 and the commencement of PARC in 1999, the Government of Kenya funded rinderpest campaigns mainly in the arid and semi-arid lands (ASALs). During this time, PARC facilitated the purchase of equipment and vehicles which were used for routine country-wide annual vaccination against rinderpest and contagious bovine pleuropneumonia (CBPP) using government funds. Between 1988 and 1998, 26,560,774 head of cattle were vaccinated against rinderpest as shown in Table 5 (Kariuki et al., 1999).

Table 5. Number of cattle vaccinated in Kenya between 1988 and 1998

	Head of cattle vaccinated for	
Year	**Rinderpest**	**CBPP**
1988	1,153,355	543,495
1989	2,557,209	697,448
1990	2,983,710	907,746
1991	2,112,376	1,089,090
1992	1,968,502	1,012,283
1993	2,385,890	1,317,396
1994	1,939,632	1,487,772
1995	2,318,400	1,322,000
1996	1,938,000	1,996,000
1997	3,517,800	1,392,693
1998	3,685,900	1,838,000
Total	**26,560,774**	**13,603,923**

Source: Kariuki et al. (1999)

[1]STABEX funds obtained from the Food and Agriculture Organization (FAO) were used (Original PACE Kenya Global Draft Document, p.3).

1.3.4 PACE

PACE-Kenya was implemented in two phases; Phase I ran between by March 2001 and October 2004 while Phase II was implemented between November 2004 and October 2006. PACE's main goal was to strengthen Kenya's capacity to plan, implement, monitor and evaluate the control of epizootic diseases (including CBPP) with private sector participation[1]. The key strategy was to eradicate rinderpest in accordance with the OIE pathway through continuous surveillance, both for verification and proof of disease absence, while at the same time preventing infection in disease free zones[2]. The total project expenditure was Euro 3,127,106 with which 235,940 head of cattle were vaccinated. The last rinderpest outbreak in Kenya was reported in 2001 in buffalos in the Meru National Park. Vaccination of cattle ceased in 2003[3]. Kenya applied to the OIE for official recognition of freedom from disease status on a zonal basis in 2005 and this was granted in May 2006.

1.3.5 SERECU

Like in the case of Ethiopia, SERECU-Kenya was launched in 2006 as part of the regional effort to coordinate the final eradication of rinderpest from its last remaining focus by 2010. The project has two phases; Phase I run between January 2005 and February 2007 while Phase II commenced in May 2008 and is expected to end in June 2010. Expenditures for phases I and II are Euro 600,000[4] and Euro 969,653 respectively.

Now that rinderpest is almost eradicated from the face of the earth, it has become imperative to take stock of the gains made by the various rinderpest eradication projects. In this regard, the AU-IBAR commissioned this study to evaluate the costs and benefits of rinderpest eradication from Ethiopia and Kenya.

1.4 Terms of Reference

The overall objective of this study is to estimate the socio-economic benefits of eradicating rinderpest in Ethiopia and Kenya. The specific objectives were to;

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[1]PACE-Kenya Final Technical Report, p. 6.
[2]Kenya country dossier for rinderpest infection freedom status (2008), p. 17.
[3]Rinderpest contingency plan for Kenya (2008).
[4]Assumed to be part of the Euro 1.818 million allocated to Ethiopia, Kenya & Somalia.

1. Determine the socio-economic benefits of eradicating RP in Ethiopia and Kenya;
2. Determine the socio-economic benefits of eradicating RP at the farmers' level;
3. Estimate the economic impacts of the outbreaks of RP in Ethiopia and Kenya and the monetary value of production losses, and
4. Determine the benefits of eradicating RP at the national veterinary department level.
5. Determine the benefits of eradicating RP at AU-IBAR level.

1.5 Rationale for the study

The global efforts to rid the world of rinderpest are almost coming to fruition if the last rinderpest focus in the Somali ecosystem is declared free in 2010. If this is achieved, rinderpest will be the second disease after smallpox and the first among animal diseases to be wiped from the face of the earth. This success heralds new possibilities of eradicating other pervasive livestock diseases using experiences and capacities developed during the rinderpest eradication. It also creates opportunities for increasing livestock productivity at the farm level and expanding trade in livestock and livestock products from affected countries. Great lessons have been learnt; experience and knowledge has been accumulated through effective collaboration and networking. This stock of "social capital" will be useful in the next campaign to eradicate other livestock diseases in future.

With rinderpest almost eradicated, the question that arises is: has the rinderpest eradication generated sufficient benefits to justify the public expenditures incurred? Money is fungible and therefore has an opportunity cost. Investing money in one program such as the rinderpest eradication program precludes the use of the same funds in alternative development endeavors. Therefore, a country has to contend with current or future benefit streams foregone once funds have been invested in a particular project. Governments in sub-Saharan African (SSA) countries are increasingly being confronted with diminishing fiscal resources amidst huge budget deficits and burgeoning human population. At the same time, donor funding is decreasing, partly due to recent global economic recession and partly due to alternative demands on funds in donor countries. Decreasing budgets coupled with increased demand for food means that SSA governments must make appropriate investment choices in an effort to maximize the welfare of their citizens. Once the investment decision has been made, investors (governments and donors) need to know not only the nature of impact their investment has had on society but also whether or not the benefits from their investment justify the costs incurred. Such information may be useful when considering future investments in similar control interventions for other livestock diseases.

This study attempted to estimate the socio-economic benefits of eradicating rinderpest from Ethiopia and Kenya. The information generated from the study will contribute to AU-IBAR's understanding of the nature and magnitude of impact that its campaigns (JP15, PARC, PACE and SERECU) have had on the economies of the two East African countries. This study complements that of Tambi et al. (1999) who undertook a cost-benefit analysis of the PARC project implemented in 10 countries – Benin, Burkina Faso, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Mali, Senegal, Tanzania and Uganda. However, while Tambi's study provides an important comparative baseline study, the current study differs from it in that it focuses on four projects in two East African countries. Additionally, due to lack of data, the assumptions made in this study are different from those made by Tambi and his colleagues.

1.6 Organization of the report

This report is organized as follows: Chapter 1 gives the background information on rinderpest and efforts directed towards its eradication from the African continent. It also gives the objectives and the rationale of the study. Chapter 2 presents the methodology used in the study to collect and analyze the data. Chapter 3 presents the results of the analysis. In Chapter 4, the results are discussed. Chapter 5 gives the conclusions of the study.

2. Methodology

2.1 Theoretical framework

Livestock production is a process of transforming inputs (land, labor, capital and entrepreneurship) into outputs (e.g. milk, meat, draught power, etc) to meet specific farm goals (McInerney, 1996). As such, a livestock production system can be represented by a production function;

$$Q = f(R/N,K) \qquad (1)$$

where Q is the quantity of output (e.g. milk, weight gain, etc) derived from the application of variable resources, R (e.g. feed, labour, etc) to an animal herd/population, N , and other fixed resources, K (e.g. land). Livestock disease lowers Q either by increasing the mortality rate (reducing N) or by reducing the efficiency of inputs R (Chi, 2001). This gives the production function shown in equation (2), where superscript D denotes disease presence.

$$Q = f^{D}(R/N,K) \qquad (2)$$

Equations (1) and (2) are plotted in Figure 3. The presence of livestock disease at the farm level means that producers operate on a lower production function ("Diseased" as opposed to "Healthy" in Figure 3) than if there were no disease (Bennett, 2003). Thus, the presence of livestock disease has two major effects at the farm level: (i) it reduces the amount of output obtained at a given level of input, e.g., $Q_H > Q_H^D$, and (ii) it induces the use of extra resources to neutralise its negative effects, e.g., $R_H > R_L$. Disease control/eradication is an attempt to move from a "diseased" to a "healthy" state, thereby reducing the potential loss in output denoted by $Q_H - Q_H^D$. It also restores the quality embodied in the product, e.g. food safety, grade, color, etc, thereby permitting trade in livestock and livestock products. It has been shown that consumers are generally willing to pay a premium price for high quality livestock products (Peng et al., 2005).

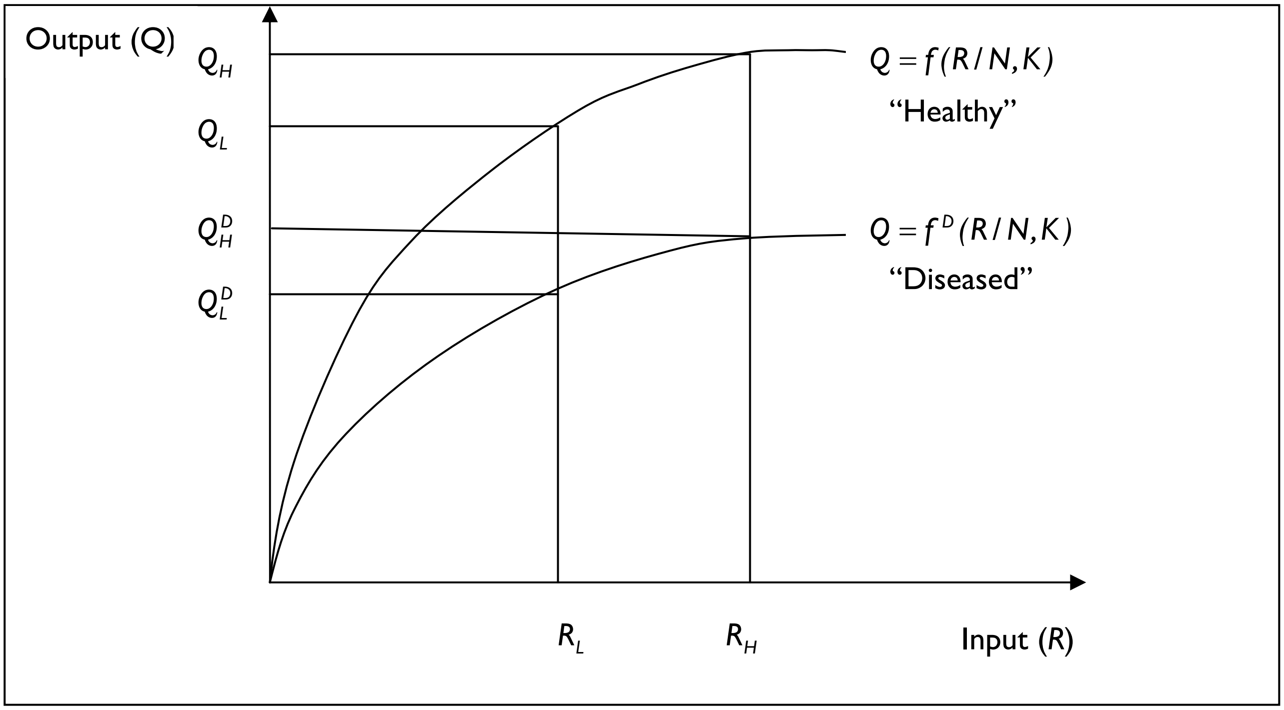

Figure 3. Effects of disease on livestock output

Source: Adapted from McInerney (1996)
N.B. H = High; L = Low; D= Diseased

2.2 Analyzing the cost of disease

The economic cost of any disease is the monetary sum of its direct and indirect impacts. Bennett (2003) defines the direct cost of disease, *C*, as

$$C = L + R + T + P \tag{3}$$

where

L= sum of the value of output loss due to the disease

R= increase in expenditure on non-veterinary resources due to the disease (e.g., feed, farm labor, etc)

T= cost of inputs used to treat the disease

P= cost of disease prevention

In this study, we expand Bennett's equation (3) to capture the opportunity cost of foregone export trade in livestock products, E. This is because the presence of a trade-sensitive disease (such as rinderpest) in a country (or region where the country is located) elicits international trade bans from potential importers in accordance with the WTO SPS agreement. This denies the country an opportunity to earn much need foreign exchange. Thus, equation (3) becomes

$$C = L + R + T + P + E \tag{4}$$

However, E was subsumed within the production losses saved from rinderpest eradication in each country to avoid double counting.

The indirect costs of a disease are generally difficult to measure because they involves nonmarketed items such as impacts of disease on human health (particularly for zoonotics, e.g., avian influenza), animal welfare, and losses arising from the preclusion of livestock production from vast geographical areas due to the presence of either the disease or its vector (e.g., trypanosomosis). Nevertheless, new approaches such as cost of illness (Tarricone, 2006) and friction cost method (Koopmanschap et al., 1995) are increasingly being used to value the impact of disease on human health.

This study attempted to estimate both the output losses and input expenditures associated with rinderpest eradication in Ethiopia. Accordingly, the study estimated the value of $Q_H - Q_H^D$ and $R_H - R_L$ in Figure 3, which is a measure of the direct costs due to rinderpest incidence in the national livestock population compared to a situation where the disease incidence was zero. These costs constitute the value of benefits of rinderpest eradication from the Ethiopian and Kenyan livestock populations. These benefits were compared with the cost of implementing JP15, PARC, PACE and SERECU, using an *ex post* social cost-benefit analysis (CBA) framework.

Social CBA studies the effect of an intervention (or project) on society as a whole, taking into account all the benefits and all the costs regardless of who spends the money or to whom the benefits accrue (Shaw, 2003). The basic approach involves aggregating all incremental costs associated with the intervention and comparing these costs to the total value of benefits generated attributable to the intervention (Tambi et al., 1999). Because costs and benefits occur over several years, their values must be appropriately discounted to account for the time value of money. Discounting gives cost and benefit values relatively less weight the further into the future they accrue. In practice, the comparison of costs and benefits is achieved using three principal financial measures; (i) net present value (NPV), (ii) benefit cost ratio (BCR) and (iii) internal rate of return (IRR).

The NPV is the sum of the present values (PVs) of individual cash flows (both cash outflows and inflows) incurred or accruing on a project over time (Brigham and Houston, 1998). The present values are obtained by discounting the cash flows using an appropriate discount rate (see below) to account for the time value of money. NPV provides a basis on which to determine whether the return on a project will be positive or negative, and with which to compare different potential projects. As a rule, projects with positive NPVs are accepted. For multiple mutually exclusive projects, the one with the highest NPV is accepted. Theoretically, the NPV assures the achievement of Pareto efficiency (which has important implications on social welfare) in that for any project with a positive NPV, it is possible to find a set of transfers that makes at least one person better off without making anyone else worse off (Boardman et al., 2001). Mathematically, the NPV is given by:

$$NPV = \sum_{t=0}^{n} \frac{B_t}{(1+s)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+s)^t} = \sum_{t=0}^{n} \frac{NB_t}{(1+s)^t} \quad (5)$$

where B_t is the value of benefits at time *t*, C_t is the value of costs at time *t*, *s* is the social discount rate, and $\frac{1}{(1+s)^t}$ is the discounting factor. NB_t represents the net benefits at time *t*.

BCR measures the total financial return for each shilling invested (Boardman et al., 2001). It provides a measure of the efficiency with which limited funds are utilized to generate the realized benefits. Like in the case of NPV, both benefits and costs are discounted using an appropriate discount rate. The BCR is given by the following formula:

$$BCR = \sum_{t=0}^{n} \frac{B_t}{(1+s)^t} \Bigg/ \sum_{t=0}^{n} \frac{C_t}{(1+s)^t} \quad (6)$$

where B_t, t, C_t and s are the same variables as previously defined.

The IRR is that discount rate which, when applied to the future streams of project costs and benefits, produces a NPV of zero (Brigham and Houston, 1998). It expresses the returns to the investment in the project as an interest rate. It therefore permits the comparison of the returns to investment in the current project with the returns to investment in other possible projects or to simply investing the funds in an interest-earning bank account. Mathematically, IRR is expressed as:

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+IRR)^t} = 0 \quad (7)$$

where CF_t is the cash flow [either cash outflow or inflow] at time t, and IRR is the internal rate of return. The idea is to solve equation (7) for the IRR.

One of the weaknesses of the CBA is that it assigns equal weights to the costs and benefits produced by a project for the poor as for the rich; yet justice requires that priority be given to those in society who are relatively worse off (Copp, 1987). The other weakness is that CBA, particularly the *ex ante* type, assumes that future project cashflows are known with certainty and that future events are predictable. Such assumptions are unrealistic in practice (Quah and Tan, 1999). Finally, CBA mainly uses market values of costs and benefits; costs and benefits of non-marketed goods or services are generally ignored. This has important implications on the final results. Nevertheless, CBA has been widely used in many studies to justify public investments (see Boardman et al. (2001) for examples). In fact, in some countries (e.g., USA), a CBA is mandatory prior to the approval of any public project.

2.3 Data type and sources

Pursuant with the objectives of this study, the following methods were used to collect the data used in the study (Table 6).

Table 6. Data collection methods by objective of the study

Objective	Data type	Source	Data collection method(s)
1	National level livestock population series from 1961	Livestock statistics	- Downloads from FAOSTAT
	Costs/expenditures for JP15, PARC, PACE, SERECU	- Project reports	- Visits and interviews with project leaders in Ethiopia and Kenya
	Incidence of rinderpest from 1961	- Project reports	- Visits and interviews with project leaders in Ethiopia and Kenya - Literature review
2	Incidence of rinderpest in selected farmers' herds	- Questionnaire interviews	- Farmers' questionnaire administration
3	National level livestock population series from 1961	Livestock statistics	- Downloads from FAOSTAT
	Incidence of rinderpest from 1961	- Project reports	- Visits and interviews with project leaders in Ethiopia and Kenya - Literature review
	Monetary value of livestock products – live animals, meat, milk, hides & skins, manure & traction power in Ethiopia & Kenya	- Market studies - Experiments e.g. on draft power	- Literature review - Interviews with technical experts
4	Capacity building at laboratory level	- Project reports	- Interviews with key informants in Ethiopia and Kenya
5	Benefits at AU-IBAR level	- Project reports	- Interviews with key informants in Kenya

In Ethiopia, three key informants (veterinary officers) were interviewed in Addis Ababa between 23rd and 28th December 2009. Five key informants from the livestock keeping community were also interviewed using a semi-structured questionnaire during the same period.

In Kenya, two senior veterinary officers at the Kabete Vetlabs in Nairobi and four field veterinarians in Garissa District/Provincial Headquarters were interviewed between January and February 2010. Twenty three livestock keepers were interviewed in Bura, Masalani, Saka and Hargabul in the larger Garissa District during the same period using a semi-structured questionnaire.

2.4 Data analysis

2.4.1 Estimation of costs of rinderpest eradication

As noted elsewhere in this report, different projects (JP15, PARC, PACE and SERECU) were implemented by the Ethiopian and Kenyan governments and their partners with the sole purpose of eradicating rinderpest. It is worth noting that vaccination was the principal activity undertaken in JP15, PARC and partly PACE. Therefore, the major cost of vaccination in each campaign was taken to be the project cost. For SERECU however, the total project expenditure was deemed the project cost. These costs constitute elements P and R in equation (3). The costs were obtained from the project budget outlays (see Tables 7 and 8 for Ethiopia and Kenya respectively). Appropriate currency conversions were made to obtain a singular numeraire. Because rinderpest has neither a known carrier state nor a chronic form (Mariner et al., 2005), the cost of treatment, T, in equation (3) was assumed to be zero.

Table 7. Cost of various rinderpest eradication projects in Ethiopia

Project	Estimated cost	Dates	Period (years)	Source of data
JP15	Birr 1,984,800†	1970-1976	6	MOARD (2009)
PARC				
Phase I	ECU 4,512,000	1989-1991	2	MOARD (2009)
Phase II	ECU 4,300,000	1991-1994	3	MOARD (2009)
Phase III	ECU 9,000,000	1994-1999	5	MOARD (2009)
Phase III extension	ECU 2,807,000			MOARD (2009)
PACE	Euro 7,200,000	2000-2004	4	MOARD (2009)
SERECU I	Euro 606,000*	2006-2007	1	http://www.au-ibar.org/documents_public/solicep Inception%20IBAR %20SERECU%20II.pdf
SERECU II	Euro 389,000	2007-2008	1	Interview with Dr Amsalu

†This represents operational costs only; data on overhead and investment costs are missing
*Derived from the total SERECU I budget of Euro 1.818 million for the 3 Somali Ecosystem countries.

Table 8. Cost of various rinderpest eradication projects in Kenya

Project	Estimated cost	Dates	Period (years)	Source of data
JP15	US$ 319,614†	1968-1971	3	
PARC	ECU 2,400,000	1997-1999	2	Project document
PACE	Euro 3,127,105.97	2001-2006	5	Project document
SERECU I	Euro 606,000*	2005-2007	2	http://www.au-ibar.org/documents_public/solicep Inception%20IBAR %20SERECU%20II.pdf
SERECU II	Euro 969,653.33	2008-2010	2	Interview with Drs Mosabi & Mureithi at Kabete Vetlabs

Source: Various
† Due to lack of on JP15-Kenya, its cost was assumed to be 1/3 the cost of JP15-Ethiopia.
*Derived from the total SERECU I budget of Euro 1.818 million for the 3 Somalia Ecosystem countries.

2.4.2 Estimation and valuation of benefits of rinderpest eradication

2.4.2.1 Identification of benefits of rinderpest eradication

The benefits of rinderpest eradication are many and accrue at different levels. Both direct and indirect benefits are shown in Table 9.

At the farm level, direct benefits comprise the production losses avoided due to rinderpest eradication. The losses avoided include values of meat, milk, draught power and manure saved. The sum of these losses constitutes L in equation (3). Indirect benefits at the farm level include enhanced food security.

At the national level, the direct benefits include export losses avoided of meat and milk. These were taken to be a fraction of the total value of production losses avoided to avoid double counting. Indirect benefits at the national level include enhanced quality assurance of animal and animal products from Ethiopia and Kenya in keeping with OIE's SPS standards. Other indirect benefits include the capacity built over the years (in terms of human and physical resources, e.g., laboratories and vaccine production units) to control other animal diseases in future.

AU-IBAR and partners benefit by the fulfillment of their continental mandate of coordinating disease control. The lessons learned and the networks created could be used in the eradication of other pervasive animal diseases in future.

Table 9. Direct and indirect benefits of rinderpest eradication

Level	Benefits	
	Direct	**Indirect**
Farm	Production losses avoided	Enhanced food security
National	Export losses avoided	Enhanced quality assurance of animal and animal products Enhanced disease control capacity in Ethiopia and Kenya
AU-IBAR	Fulfillment of continental mandate	Lessons learnt that could be used in the eradication of other diseases in future

2.4.2.2 Calculation of production losses avoided

The production losses avoided were calculated from the values of meat, milk, manure and traction saved as a result of rinderpest eradication. For each of the four projects (JP15, PARC, PACE, SERECU), the benefits were restricted to life of the project. The calculation was based on a "with" and "without" project approach.

Cattle population data were obtained from FAOSTAT (2010) due to lack of consistent country-level data series covering the study period. The number of cattle saved from death due to rinderpest in Ethiopia was calculated using mortality rates given in Tambi et al. (2004; p. 743) of 3.86% and 1% for severe and mild rinderpest outbreaks respectively under the "no intervention" scenario. It is worth noting that the rinderpest virus strains circulating in East Africa cause mild to moderately severe clinical disease in cattle compared to those in the Middle East which induce severe mortality (Nores and McCullough, 1997). The dates when rinderpest outbreaks occurred in Ethiopia and Kenya (Tables 10 and 11 respectively) were obtained from the literature.

Table 10. Recorded rinderpest outbreaks in Ethiopia

Year	Region	Reference
1887	Eritrea, Tigray & Shewa	Abraham et al. (1998)
…		
1975	South east Ethiopia	Roeder & Rich (2009)
1976	Afar	Rweyemamu (1996)
1979	Country-wide	Rweyemamu (1996)
1980	Several outbreaks	Abraham et al. (1998); Kouba (2003)
1982	Tigray	Roeder & Rich (2009)
1983	Afar	Roeder & Rich (2009)
1985	Unrecorded	Kouba (2003)
1989	Country-wide	Abraham et al. (1998)
1992	Arsi/Bale highlands	Rweyemamu (1996); Tambi et al., (1999)
1994	Arsi/Bale highlands	Rweyemamu (1996)
1994	North-eastern Ethiopia	Rweyemamu (1996); Abraham et al., 1998)
1995	Afar	Tambi et al. (1999)
1995	Asmara	FAO (1996)

Table 11 shows the dates of recorded rinderpest outbreaks in Kenya. It appears from Table 9 that Kenya did not experience major rinderpest outbreaks in cattle between 1968 and 2008. In regard of this observation and lack of rinderpest incidence data, we assumed a rinderpest-induced cattle mortality of 1% for the four projects implemented in Kenya.

Table 11. Recorded rinderpest outbreaks in Kenya

Year	Region	Reference
1893	Maasailand	F.J.D. Lugard recorded in http://www.iah.bbsrc.ac.uk/disease/rinderpest1.shtml
1911	North Nyanza	Waller (2004)
1925-1940s	Country-wide	Waller (2004)
1960-1967	Country-wide	http://www.mifugo.go.tz/documents_storage/ Rinderpest%20 Emergency%20Preparedness%20& %20Response%20Plan.pdf
1980	Western Kenya	Rossiter et al. (1983)
1986	Western Kenya	Wafula and Kariuki (1987)
1986-92	Country-wide	PACE Kenya Final Technical Report
1994	Tsavo East in wildlife; no cattle infected	www.taa.org.uk/rinderpest.pdf
1995	Tsavo National Park in wildlife; no cattle infected	Kariuki et al. (1999)
1996	Nairobi National Park in wildlife; no cattle infected	www.taa.org.uk/rinderpest.pdf
	Mandera – No cattle infected	
	Kajiado – No cattle infected	
1997	Southern Rift Valley in wildlife; no cattle infected	Kock et al. (1999)
2001	Meru National Park; cattle infected	Kenya country dossier for rinderpest infection freedom status (2008)

Because the FAOSTAT cattle population data are aggregated, appropriate assumptions were made, based on existing literature, to enable the disaggregation of the data (Table 12).

Table 12. Assumptions on cattle data for Ethiopia and Kenya

Item	Ethiopia		Kenya	
	Assumed value	**Source of information**	**Assumed value**	**Source of information**
Adult cattle	82.8% of cattle population	Mariner et al. (2005)	80% of cattle population	
Young cattle	17.2% of cattle population	Mariner et al. (2005)	20% of cattle population	
Average carcass weight – young cattle	50kg	Interview with Dr Edmealem	50kg	
Average carcass weight by breed – adult cattle	110kg for local; 120kg for grade	Interview with Dr Edmealem	113kg for local; 143kg for grade	Kivunja (1978)
Proportion of cattle by breed	99% local; 1% grade	UNIDO (2009)	72% local; 28% grade	Njubi et al. (2009)
Proportion of milkers by breed	20% of local; 80% of grade		10% of local; 90% of grade	Authors
Milk yield by breed	1.5Kg/day for local; 9Kg/day for grade	Interview with Dr Edmealem	1Kg/day for local; 11.3Kg/day for grade	Reynolds et al. (1996)
Lactation length by breed	Local breeds = 180 days; Exotic/grade = 270 days	Interview with Dr Edmealem	239 days for local; 302.5 days for grade	Mosi and Inyangala (2004)
Manure production	<u>Adults:</u> Local breeds = 2.27kg/hour/day/animal; Exotic/grade = 2.01kg/hour/day/animal	http://www.gcrio.org/CSP/IR/IRethiopia.html	<u>Adults:</u> Local breeds = 2.27kg/hour/day/animal; Exotic/grade = 2.01kg/hour/day/animal	http://www.gcrio.org/CSP/IR/IRethiopia.html
	<u>Young:</u> 0.5kg/hour/day/animal		<u>Young:</u> 0.5kg/hour/day/animal	
	14% of manure is the solid portion	http://siteresources.worldbank.org	14% of manure is the solid portion	http://siteresources.worldbank.org
Draught animal population	9 to 10 million or 33% of adult cattle population	Astatke and Saleem (1996)	6.2% of cattle population	Mrema and Mrema (1993)
Length of time worked by a	60 days per year	Zerbini and Larsen (1996)	6 days per year	Onyango (1990)

pair of oxen				
Number of hides	Adult beef and dry grade cattle population. Only 50% of hides are of marketable quality		Adult beef and dry grade cattle population. Only 50% of hides are of marketable quality	
Weight of a hide	12kg for an adult hide (dry salted)	http://www.intracen.org	12.5kg for a low grade hide	Kivunja (1978)

2.4.2.3 Valuing benefits

Price data are needed to value benefits. However, as is common in most developing countries, the price data for the various products (meat, milk, draught and hides) were not readily available despite deliberate effort to obtain them from key informants. This was particularly acute for manure and traction power, which generally are non-marketed goods. Consequently, price data were obtained from different sources as described below.

Beef and milk producer prices were obtained from FAOSTAT (2010) price series for the period 1991 to 2007. Beef producer prices for 1968 to 1990 were obtained from the literature. Those for 2008 were extrapolated from the 2001-2007 series assuming a linear trend. Table 13 shows the average producer prices for beef for Ethiopia and Kenya. In general, average beef price was higher in Kenya than in Ethiopia. The converse is true for milk price.

Table 13. Average beef and milk producer prices for Ethiopia and Kenya (1968-2008)

Country	Commodity	Period	Average price (US$/MT)	Range (US$/MT)
Ethiopia	Beef	1970-2008	1,048.9	260-2,630
	Milk	1970-2008	308.0	181.1-478.2
Kenya	Beef	1968-2008	1,360.4	405.1-2,162.4
	Milk	1968-2008	213.7	165.5-318.0

The average price of hiring a pair of oxen in Ethiopia was obtained from an interview with Dr Berhanu Gebremedhin, the coordinator of ILRI's IPMS in Addis Ababa, who have extensive experience in livestock marketing. During the interview, he indicated that the current price of hiring a pair of oxen is ETB 50 (or US$ 3.97)[1] per day. In Kenya, the average price for hiring a pair of oxen was taken to be KShs 200 (or US$ 2.72)[2] per day (Dr P. Guthiga, Personal communication)[3].

Due to lack of data on manure prices, we imputed the price from Franke et al. (2008), who reported a farm-gate price of US$ 10.4/MT in northern Nigeria. As expected, there were no manure prices for different years for the two countries.

The price of a hide used in this study was US$ 0.3/kg obtained from the International Trade Centre website (http://www.intracen.org/Appli2/Leather/AfricanPlatform). Like in the case of manure, there were no hide prices for different years for the two countries.

In all cases, the value of benefits was calculated by multiplying the quantity of the benefit with the corresponding price (in US$) for that year.

2.4.2.4 Valuing costs

As shown in Tables 7 & 8, the project costs were denominated in different currencies. To convert these currencies into a common currency (US$), the nominal exchange rates for different years for the two countries were obtained from the literature (Table 14).

[1]At current exchange rate of US$ 1 = ETB 12.6.
[2]At current exchange rate of US$ 1 = KShs 73.5.
[3]Lecturer, Department of Agricultural Economics, University of Nairobi.

Table 14. Nominal average exchange rates for various currencies for which the project costs in Ethiopia and Kenya were denominated

Project	Currency of project costs	Project period	Exchange rate	Source of information
JP15	Ethiopian Birr	1970-1976	ETB 2.07 to 1US$ (fixed rate)	Dercon (2002)
PARC	ECU	1989-1999	US$ 1.19581 to 1 ECU (average)	http://www.economagic.com
PACE	Euro	2000-2004	US$ 1.02798 to 1 Euro (average)	http://sdw.ecb.europa.eu
SERECU	Euro	2006-2008	US$ 1.365633 to 1 Euro (average)	http://sdw.ecb.europa.eu

2.4.2.5 Choice of social discount rate

It was noted in Section 2.2 that in calculating the NPV, BCR and IRR of a project, it is necessary to discount future cost and benefit streams into their present values. The rationale for this practice is to account for the time value of money. The notion of time value of money is easy to conceptualize: a shilling at hand today is worth more than a shilling earned in the future because of the opportunity cost of money. Additionally, societies tend to have varying time preferences for present or future consumption.

A social discount rate is used in this regard to guide choices about the value of diverting public funds to social projects. According to Boardman et al. (2001), the choice of an appropriate social discount rate is not trivial; different social discount rates change the ranking of projects resulting in varying policy prescriptions. However, there is no consensus among economists on how to choose an appropriate social discount rate. The proper social discount rate should be one that represents the opportunity cost of investing the funds in an alternative project. In this study, the social discount rate was derived from the average annual nominal lending rates of commercial banks in Ethiopia and Kenya obtained from the literature.

Between 1970 and 1989 lending rates in Ethiopia were fixed by the government (then called '*The Derg*') at 12% per annum (Osborne, 2002). Thereafter, the rates were liberalized (Table 15). These rates were used in this study to discount the costs and benefits of different rinderpest eradication projects in Ethiopia.

Table 15. Prevailing average annual nominal lending rates of commercial banks in Ethiopia (1970-2008)

Year	Lending rate (%)	Source of information
1970-89	12.0	Osborne (2002)
1990-91	6.0	http://www.thedti.gov.za/econdb
1992	8.0	
1993	14.0	
1994	14.3	
1995	15.1	
1996	13.9	
1997-98	10.5	
1999	10.6	
2000-01	10.9	
2002	8.7	
2003	7.5	
2004-07	7.0	
2008	7.5	http://www.combanketh.com

Table 16 shows the prevailing average annual nominal lending rates of commercial banks in Kenya between 1968 and 2008. These rates were used to discount the costs and benefits of different rinderpest eradication projects in Kenya.

Table 16. Prevailing average annual nominal lending rates of commercial banks in Kenya (1968-2008)

Year	Lending rate (%)	Source of information
1968-70	7.00	Mwega et al. (1990)
1971	8.00	Central Bank of Kenya http://www.centralbank.go.ke/downloads/publications/mer/2009/Oct09.pdf
1997	28.30	
1998	29.49	
1999	22.38	
2001	19.67	
2002	18.50	
2003	16.36	
2004	12.53	
2005	12.89	
2006	13.63	
2007	13.33	
2008	14.02	

3. Results

3.1 Contribution of rinderpest eradication projects to total benefits

3.1.1 Ethiopia

Table 17 shows the total benefits of rinderpest eradication in Ethiopia. The benefits were disaggregated into various animal products across the four projects.

Table 17. Incremental benefits derived from rinderpest campaigns in Ethiopia

Project	Benefits (US$ Million)					
	Beef	**Milk**	**Manure**	**Traction**	**Hides**	**Total**
JP15	107.88	0.05	53.04	0.37	2.94	164.29
PARC	502.05	0.19	109.56	0.77	6.08	618.65
PACE	58.84	0.03	29.94	0.21	1.66	90.69
SERECU	54.19	0.03	22.02	0.16	1.22	77.62
Total	**722.96**	**0.30**	**214.56**	**1.51**	**11.91**	**951.25**

The total benefits of rinderpest eradication in Ethiopia amounted to US$ 951.3 million. PARC had the highest contribution amounting to US$ 618.7 million or 65% of total benefits. It was followed by JP15 at 17.3%, PACE (9.5%) and SERECU (8.2%). The reason why PARC had the largest contribution to the total benefits could be because it lasted the longest of the four campaigns. It also had the second largest cattle population growth rate of 2.5% per year after SERECU with 6.9%. PACE and JP15 had 2.3% and negative 0.5% annual cattle growth rates, respectively.

The largest proportion (76%) of the benefits came from beef, probably because a large proportion of cattle (99%) in Ethiopia is of indigenous type, that is mainly kept for meat (UNIDO, 2009). Manure contributed 22.5% of the benefits while hides, traction and milk contributed 1.3%, 0.2% and 0.03% of the total benefits, respectively. Surprisingly, milk had an almost insignificant contribution to total benefits although it is major product of cattle production. Manure had a substantial contribution. Although manure is mainly non-marketed, it is a valuable by-product of cattle production in Ethiopia, particularly if one considers its linkage with crop agriculture and household cooking energy.

3.1.1.2 Kenya

Table 18 shows the total benefits of rinderpest eradication in Kenya. The total benefits were US$ 433.97 million, about 50% of the benefits accruing to Ethiopia. Of these, PACE contributed the largest proportion of 43.7%. It was followed by PARC, SERECU and JP15 with 22.4%, 21.2% and 12.7% respectively.

Table 18. Incremental benefits derived from rinderpest campaigns in Kenya

	Benefits (US$ Million)					
Project	**Beef**	**Milk**	**Manure**	**Traction**	**Hides**	**Total**
JP15	8.15	39.10	7.37	0.27	0.31	55.16
PARC	32.41	56.25	8.00	0.29	0.34	97.30
PACE	73.74	98.00	1.67	0.61	0.71	189.71
SERECU	31.80	53.64	5.89	0.21	0.25	91.80
Total	**146.10**	**246.93**	**37.94**	**1.38**	**1.62**	**433.97**

Figure 4 shows the contribution of various cattle products to the total benefits of rinderpest eradication in Kenya. Unlike in Ethiopia where beef dominated, in Kenya milk had the largest contribution to the total benefits of about 57%. This was followed by beef at 34% and manure at 9%. Hides and traction had insignificant contribution to the total benefits.

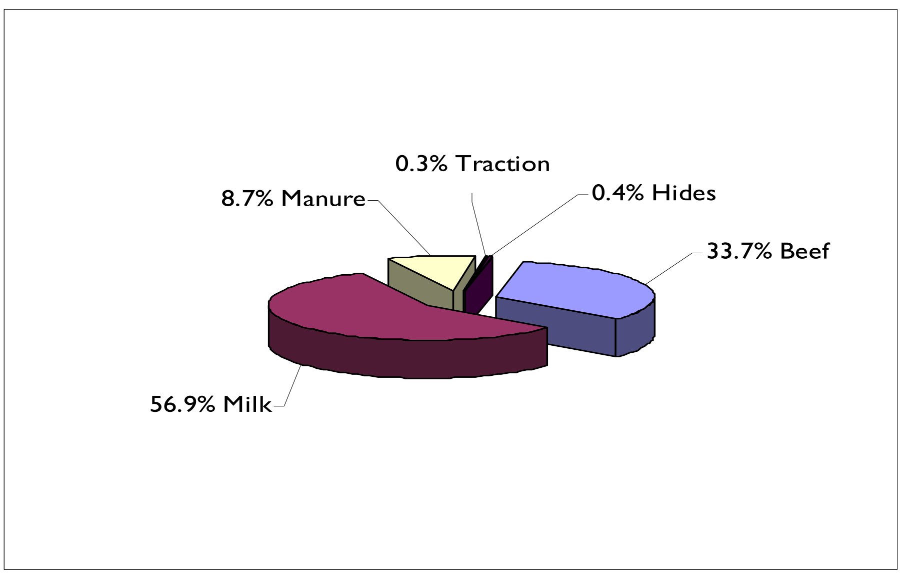

Figure 4. Contribution of cattle products to total benefits of rinderpest eradication in Kenya

3.2 Comparison of costs and benefits of rinderpest eradication

3.2.1 Ethiopia

The costs and benefits of rinderpest eradication were compared using NPV, BCR and IRR in a CBA framework. Table 19 presents the results of the CBA for Ethiopia.

The NPVs for the four projects were highly positive implying that rinderpest eradication campaigns generated substantial returns to the Ethiopian society and produced benefits that covered the initial investment. Of the total discounted net benefits amounting to US$627.4 million generated by the eradication campaigns, PARC had the largest NPV of US$ 404.2 million (representing 64.4% of total NPV), followed by JP15 with US$ 85.3 million (13.6%), SERECU with US$ 76.4 million (12.2%), while PACE had the least, US$ 61.6 million (9.8%).

Table 19. NPV, BCR and IRR of rinderpest eradication projects in Ethiopia

Project	NPV (US$)	BCR	IRR (%)
JP15	85,296,297.3	138.0	5.1
PARC	404,152,033.9	31.8	33.8
PACE	61,610,147.9	12.7	2.6
SERECU	76,374,774.1	78.6	18.8
Total	**627,433,253.2**		

During JP15, PARC and PACE projects 89, 57 and 3 million cattle were vaccinated, respectively, (Section 1.2). Accordingly, the net present value per vaccinated bovine was US$ 0.96, US$ 7.09 and US$ 20.54 for JP15, PARC and PACE respectively.

As shown in Table 19, the benefit-cost ratios for the four projects were fairly high, except for PACE, indicating that the benefits realized from rinderpest eradication campaigns far outweighed project costs. This means that each dollar invested in JP15, PARC, PACE and SERECU yielded a return of US$ 138, US$31.8, US$ 12.7 and US$ 78.6, respectively. Hence, the money invested in rinderpest eradication in Ethiopia was effectively used.

The internal rate of return for JP15, PARC and SERECU was comparatively higher than the current interest rate on deposits offered by the Commercial Bank of Ethiopia of 3% per annum (http://www.combanketh.com/depositDom.php). PARC, SERECU and JP15 earned 11.3, 6.3 and

1.7 times more than alternative investment in a commercial bank. Surprisingly, PACE's internal rate of return was below the interest on deposits. While no obvious reason could be attributed to this observation, it seems that PACE did not yield an adequate return to cover the cost of invested capital, during the period of investment.

3.2.2 Kenya

Table 20 shows the financial performance of the four rinderpest eradication projects in Kenya. The net present values were highly positive, though lower than those for Ethiopia by almost 50%. PACE had the largest NPV of US$ 114.8 million (representing 39.1% of total NPV), followed by SERECU with US$ 73.5 million (25%). PARC and JP15 had US$ 59.6 million (20.3%) and US$ 45.6 million (15.5%), respectively.

Table 20. NPV, BCR and IRR of rinderpest eradication projects in Kenya

Project	NPV (US$)	BCR	IRR (%)
JP15	45,567,990.70	170.95	38.41
PARC	59,624,478.54	35.71	11.94
PACE	114,842,832.96	66.05	8.64
SERECU	73,492,999.69	42.42	20.64
Total	**293,528,301.89**		

The benefit-cost ratios were also relatively high implying that the money invested in rinderpest eradication was well utilized. JP15 had the highest BCR of 171.0 indicating that US$ 1 invested in JP15 yielded US$ 171, which is a remarkably high return on investment. PACE and SERECU had benefit-cost ratios of 66.1 and 42.4 respectively while PARC had the least benefit-cost ratio of 35.7 (Table 20).

The internal rates of return of the four projects were fairly high. When these returns were compared to the nominal average rate of return on a 91-day Treasury Bill of 7.43% for 2009, investing in JP15, SERECU, PARC and PACE earned 5.2, 2.8, 1.6 and 1.2 times higher than investing the same money in the risk-free instrument. Based on these numbers, it seems PARC and PACE had only a marginal return on investment during the study period.

3.3 Contribution of rinderpest eradication to the economy

3.3.1 Ethiopia

3.3.1.1 Contribution to GDP

Table 21 shows the contribution of the four rinderpest eradication projects to Ethiopia's GDP in 2008, assuming that agriculture contributes 45% of the total GDP (EIAR, 2007). Overall, the contribution of the four projects to the total GDP was 2.4%, or roughly 0.6% per project on average. PARC contributed 3.4% (the highest) to Ethiopia's agricultural GDP and 1.5% to the total GDP. Given that this contribution came exclusively from the value of cattle products saved, it means that investment in rinderpest eradication succeeded in raising the country's wealth.

Table 21. Contribution of various rinderpest eradication projects to Ethiopia's GDP

Project	NPV (US$ Million)	GDP for 2008 (US$ Billion)[†]	Agric GDP for 2008 (US$ Billion)	Contribution to AgGDP (%)	Contribution to GDP (%)
JP15	85.3	26.49	11.9	0.72	0.32
PARC	404.2	26.49	11.9	3.39	1.53
PACE	61.6	26.49	11.9	0.52	0.23
SERECU	76.4	26.49	11.9	0.64	0.29
Total	**627.4**	**26.49**	**11.9**	**5.26**	**2.37**

[†]CIA (2008).

3.3.1.2 Contribution to final demand and household incomes

In order to determine the contribution of the rinderpest eradication campaigns to the final demand for livestock products in the rest of the economy, and contribution to household incomes, the social accounting matrix (SAM) multipliers[1] computed by Roeder and Rich (2009) for Ethiopia were used. The SAM multipliers for the Ethiopian livestock sector and household income were 3.31% and 2.65%, respectively.

As expected, the highest contribution came from the project with the highest cost outlay, i.e., PACE (Table 22). The total increase in final demand for livestock products as a result of

[1]SAM multipliers show the impact of a unit increase in final demand for a given commodity sector on total production in the economy (Roeder and Rich, 2009; p. 36).

rinderpest eradication in Ethiopia was US$ 823,947.1, of which US$366,352.3 accrued to livestock-keeping households.

Table 22. Contribution of rinderpest eradication to final demand and household incomes in Ethiopia

Project	Cost (US$)	SAM multiplier for livestock sector†	Increase in livestock sector contribution (US$)	SAM multiplier for household income†	Increase in contribution to household income (US$)
JP15	958,840.6	0.0331	31,737.6	0.0265	25,409.3
PARC	4,974,066.4	0.0331	164,641.6	0.0265	131,812.8
PACE	6,649,920.0	0.0331	220,112.4	0.0265	176,222.9
SERECU	1,241,788.4	0.0331	41,103.2	0.0265	32,907.4
Total	**13,824,615.4**	**0.0331**	**457,594.8**	**0.0265**	**366,352.3**

†Derived from Roeder and Rich (2009).

3.3.2 Kenya

3.3.2.1 Contribution to GDP

According to CIA (2008), Kenya's GDP was estimated at US$ 62.39 billion in 2008, of which 21.4% came from agriculture. These numbers were used to calculate the contribution of the four rinderpest eradication projects to Kenya's GDP.

As shown in Table 23, the overall contribution of the four rinderpest eradication projects to the GDP was only 0.5%, which is rather small compared to the 2.4% obtained in Ethiopia probably due to the large numbers of livestock in Ethiopia relative to Kenya and the fact that Ethiopia experienced most rinderpest outbreaks in cattle than Kenya. The contribution to the agricultural GDP was 2.2%, which is 42% less than that obtained in Ethiopia. These results indicate that rinderpest eradication campaigns in Kenya had only a modest contribution to the country's total wealth, relative to Ethiopia.

Table 23. Contribution of various rinderpest eradication projects to Kenya's GDP

Project	NPV (US$ Million)	GDP for 2008 (US$ Billion) †	Agric GDP for 2008 (US$ Billion)	Contribution to AgGDP (%)	Contribution to GDP (%)
JP15	45.6	62.39	13.35	0.34	0.07
PARC	59.6	62.39	13.35	0.45	0.10
PACE	114.8	62.39	13.35	0.86	0.18
SERECU	73.5	62.39	13.35	0.55	0.12
Total	**293.5**	**62.39**	**13.35**	**2.20**	**0.47**

†CIA (2008).

3.3.2.2 Contribution to final demand and household incomes

The SAM multipliers for the Kenyan livestock sector and household income were 2.89 and 1.22 respectively (Roeder and Rich, 2009; p. 37). The PACE project had the highest contribution to both the rest of the economy as well as to household incomes (Table 24). The final demand was US$ 231,379.3 while US$ 2,822.8 accrued to the livestock keeping households.

Table 24. Contribution of rinderpest eradication to final demand and household incomes in Kenya

Project	Cost (US$)	SAM multiplier for livestock sector†	Increase in livestock sector contribution (US$)	SAM multiplier for household income†	Increase in contribution to household income (US$)
JP15	319,613.53	0.0289	9,236.83	0.0122	112.69
PARC	2,726,520.00	0.0289	78,796.43	0.0122	961.32
PACE	2,800,636.11	0.0289	80,938.38	0.0122	987.45
SERECU	2,159,432.89	0.0289	62,407.61	0.0122	761.37
Total	8,006,202.53	0.0289	231,379.25	0.0122	2,822.83

†Derived from Roeder and Rich (2009)

3.4 Indirect benefits of rinderpest eradication projects in Ethiopia and Kenya

3.4.1 Capacity-building

3.4.1.1 Human resources

3.4.1.1.1 Ethiopia

All the three key informants (veterinary officers) interviewed in Addis Ababa had knowledge of the four rinderpest eradication projects. Indeed, only one informant had actively participated in the implementation of PACE and SERECU.

According to MOARD (2009), 10 veterinarians were trained to MSc level courtesy of PARC. In addition, 20 other staff[1] attended short-term training abroad during PARC. Numerous local training programs were also implemented during PARC and PACE focusing on the following issues: passive and general disease reporting, active disease surveillance techniques, strategy and *Office International des Épizooties* (OIE) pathway, sero-surveillance, contingency planning and emergency preparedness, communication, awareness creation of veterinary privatization and business management.

Ethiopia prepared and implemented its rinderpest emergency preparedness plan during PARC (MOARD, 2009). The emergency plan involves the Ministry of Agriculture and the Regional Authorities. The main objective of this plan is to design a system for detecting rinderpest and mounting appropriate measures as early as possible (MOARD, 2009). A rinderpest contingency plan was also written and tested during PARC. Both plans are currently being revised. As such, Ethiopia has built the necessary capacity to develop both rinderpest emergency preparedness and contingency plans without recourse to consultants or external technical assistance.

One of the key informants had knowledge about participatory epidemiology (PE) and participatory disease search (PDS) although he had never applied them in the field. Both PE and PDS had been introduced during PACE. PDS is more widely used in Ethiopia than PE, particularly in the pastoralist areas, and is credited for being one of the approaches that helped Ethiopia to attain the "freedom from rinderpest" status required by the OIE. PDS has been

[1] The cadre is not specified in the report.

used variously to search for transboundary diseases including rinderpest, foot and mouth disease (FMD), Rift Valley Fever (RVF) and contagious bovine pleuropneumonia (CBPP). On the other hand, PE has mainly been used as part of postgraduate training in Ethiopia.

According to the key informants, vital lessons were learned from the approaches used in JP15, PARC and PACE projects that culminated in the eradication of rinderpest from Ethiopia. The mass vaccination of JP15 did little to eradicate the disease from Ethiopia. On the other hand, PARC's and PACE's strategic vaccination based rigorous disease surveillance led to the eradication of rinderpest from Ethiopia. Hence, a strategy of evidence-based rational vaccination is crucial in stamping out epidemic diseases such as rinderpest. According to the informants, these lessons constitute a unique model that can be used in future efforts to control and/or eradicate animal diseases.

3.4.1.1.2 Kenya

The two senior veterinarians at Kabete Vetlabs had knowledge of PARC, PACE and SERECU. They had no information on JP15 because it was implemented in the 1960s/70s when they had not joined the profession. Of the four field-level veterinarians interviewed in Garissa, three had knowledge of PARC, PACE and SERECU but not JP15. The other officer who was more elderly had knowledge of JP15 as well.

Based on the key informant interviews and documents availed to the consultant by the key informants, there no staff was trained to professional level (e.g. BSC/BVM, MSc, PhD) through the four rinderpest eradication projects. However, several staff [the number could not be established] attended short-term courses (within and outside Kenya) in epidemiology, GIS, data collection and management, diagnostic techniques, business management, project management and communication during PACE and SERECU. Part of this capacity is currently being used in control of other diseases such as *Peste des Petits Ruminants* (PPR), RVF and Highly Pathogenic Avian Influenza (HPAI).

Part of the training in epidemiology involved the preparation of rinderpest emergency preparedness and contingency plans. The two documents were developed in 2008.

Accordingly, the Kenyan veterinary personnel have the capacity to develop such documents without recourse to external consultants or technical assistance.

Some of the key informants had knowledge of PE and PDS. The two approaches are commonly used for rinderpest surveillance in Kenya. Both PE and PDS have also been used for the surveillance of FMD, CBPP, HPAI, RVF, PPR, lumpy skin disease (LSD) and black quarter.

According to the key informants at the Kabete Vetlabs, the rinderpest eradication model that involves control and eradication through strategic evidence-based vaccination and rational zoning can be adapted for the eradication of other diseases such as CBPP and FMD.

3.4.1.2 Laboratories

3.4.1.2.1 Ethiopia

The following laboratories were established (but not directly constructed) in Ethiopia during the specified rinderpest eradication campaign (Table 25).

Table 25. Particulars of laboratories involved in rinderpest investigation in Ethiopia

Period	Laboratory
Pre & during JP15	National Veterinary Institute
	Sholla Regional Diagnostic Laboratory
	Bahir Dar Diagnostic Laboratory
	Combolcha Diagnostic Laboratory
	Dire Dawa Diagnostic Laboratory
	Bedelle
	Assella
PARC	Sodo
	Mizan
	Mekele
	Sebeta National Animal Health and Diagnostic Investigation Centre (NAHDIC) (Referal). It is trying to obtain international recognition
PACE	Assossa
	Jijiga
	Semera
	Gambella (not fully functional)
	Hirna

Source: Key informant interviews

Information on the role of JP15 in strengthening the laboratory capacity was not available. However, the key informants intimated that JP15 funded the procurement of some of the laboratory equipment and consumables for use in rinderpest control in Ethiopia.

According to MOARD (2009), PARC made substantial contribution in enhancing the diagnostic capacity of Federal and Regional Veterinary Laboratories. The following diagnostic techniques were established during PARC: Agar Gel Immuno-Diffusion test (AGIDt) rinderpest Antigen Capture ELISA, PPR Antigen Capture ELISA and rinderpest competitive ELISA, PPR competitive ELISA. These techniques are now widely used in the National Animal Health Diagnostic and Investigation Laboratory. In addition, differential diagnosis BVDV antigen detection has also been introduced.

PARC also assisted in the establishment of a polymerase chain reaction (PCR) laboratory where it purchased most of the equipment and consumables to perform cell-culture for virus isolation. A serum bank was also established during PARC. Training and laboratory materials were provided by PARC for performing AGID test in all the eight regional laboratories (MOARD, 2009).

PACE also purchased most of the equipment and consumables for cattle vaccination and for strategic sero-surveillance monitoring.

Although extensive capacity has been built at the National Animal Health and Diagnostic Investigation Centre (NAHDIC) for the diagnosis of rinderpest and rinderpest-like diseases, the linkage between regional laboratories and the NAHDIC is weak and limited to referral services for tests beyond the capacity of regional laboratories (MOARD, 2009).

3.4.1.2.2 Kenya

Like in the case of Ethiopia, no laboratory was established courtesy of the four rinderpest eradication projects. However, these projects enhanced the capacity of existing laboratories through purchase of materials and equipment and the training of technical staff. Table 26 shows the laboratories that participated in rinderpest-related investigations in Kenya. These laboratories are also used to investigate other diseases such as PPR, RVF, CBPP, FMD and HPAI.

Table 26. Particulars of laboratories involved in rinderpest investigation in Kenya

Laboratory	Year of establishment	Remarks
Kabete Central Veterinary Laboratory (CVL)	1910	The central veterinary laboratory in Kenya which is a reference to the rest
Mariakani VIL	1985	Started operating in 1987. Handles veterinary investigations at the Coast Province
Kericho VIL	1975	Handles veterinary investigations in south Rift including Nyanza Province
Eldoret VIL	1975	Handles veterinary investigations in north Rift including Western Province
Karatina VIL	1976	Handles veterinary investigations in Central Province and northern Kenya
Nakuru VIL	1976	Handles veterinary investigations in central Rift Valley Province
Garissa VIL	2004	Opened in 2005. Handles veterinary investigations in North Eastern Province
Muguga NVRC	1953	Was the regional rinderpest diagnostic centre and the OIE regional reference laboratory for rinderpest and rinderpest-like diseases (e.g., PPR) until 2004 when it lost this status
Embakasi	1960	FMD laboratory but is used for differential diagnosis

Source: Interviews with key informants
VIL = Veterinary Investigation Laboratory
NVRC = National Veterinary Research Centre

It is worth noting that the Muguga NVRC acquired and lost its OIE Regional Reference Virology Laboratory status during the PACE project. The status was lost in 2004 because of loss of critical human resources and low funding. So far, none of the other laboratories have international accreditation. However, both Kabete CVL and Muguga NVRC have established networks with reference laboratories. They also have acquired rinderpest diagnostic capacity that they use before submitting samples to world reference laboratories. Only the Kabete CVL has access to containers to transport specimen in good condition to the regional or world reference laboratories in Pirbright UK and CIRAD EMVT in France.

3.4.1.3 Disease reporting

3.4.1.3.1 Ethiopia

PARC established the Federal Epidemiology Unit in Ethiopia in 1995 as a disease reporting channel. It also provided regular training and created awareness among field staff about the international obligations for rinderpest surveillance and reporting. The PARC project also established a Geographical Information System (GIS) at the national level to visualize collected data (Kariuki et al., 1999). By the end of PARC in 1999, disease reporting rate was 42.4%. Table 27 shows the number of reports received by Regional States between 1995 and 1999. In general, there was a gradual increase in the number of reports received by the Regional States between 1995 and 1999. Oromia and Amhara States received the highest number of reports over the period. PARC also created awareness amongst field staff on international obligations and requirements on disease reporting.

Table 27. Number of reports received by Regional States between 1995 and 1999

Regional State	1995	1996	1997	1998	1999	Total
Tigray	55	90	86	44	141	416
Afar	0	0	3	41	46	90
Amhara	507	617	823	763	814	3,524
Oromia	194	520	968	1,135	1,036	3,853
Somali	0	8	12	22	7	49
Ben. Gumuz	0	33	79	109	117	338
SNNP	126	332	277	314	433	1,482
Gambela	0	0	31	0	27	58
Harari	1	7	8	9	12	37
Region 14	0	25	15	15	25	80
Dire Dawa	6	3	0	12	12	33
Total	**2,884**	**3,631**	**4,299**	**4,462**	**4,669**	**19,945**

Source: MOARD (2009)

3.4.1.3.2 Kenya

It is a legal requirement that every Kenyan suspecting the presence of rinderpest reports any such suspicion at the earliest possible opportunity. Kenya has a well-established disease reporting system involving livestock keepers, CBAHWs and private animal health service providers (PAHSPs) in the rinderpest endemic areas who are organized into District Disease Control Committees (DDCC). Normally, the first contact is with the Livestock Extension

Personnel or CBAHWs. The CBAHWs report to the District Veterinary Officer (DVO). The report, action taken and the outcome of the DVO's initial investigations are recorded as rinderpest rumor in a "rumor register" at the DVO's office. If there are grounds to support the suspicion of rinderpest, the local Veterinary Officer (VO) immediately contacts the nearest VIL and the DVO, who in turn informs the respective Provincial Director of Veterinary Services (PDVS), the Chief Veterinary Officer (CVO) and the Director of Veterinary Services (DVS). This system was greatly strengthened during PARC and PACE projects. The PACE project final report indicates that the reporting rate by the PAHSPs to DVOs' offices increased from 1 to 10% in at least 60% of the districts by May 2006. Data to corroborate this assertion were however not available.

3.4.1.3 Vehicles and equipment

3.4.1.3.1 Ethiopia

There was no information on the number and condition of the vehicles and equipment (e.g. laboratory equipment) bought during JP15, PARC and PACE in Ethiopia. One key informant intimated that SERECU has released one vehicle to the Addis Ababa office.

3.4.1.3.2 Kenya

According to Kariuki et al. (1999), the emergency PARC funding purchased 39 Land Rovers, 10 Pick-ups, 3 GLC equipment for acaricide testing, 20 cold chain refrigerators. The EPERK program purchased 3 computers, 1 photocopier, 1 typewriter, 1 calculator, 46 VHF radios, 134 cool boxes, 89 tents and 30 mobile crushes. Additionally, 134 vehicles were repaired. The vehicles and equipment were used to carry out annual vaccination against rinderpest and CBPP throughout the country using funds provided by the Government of Kenya.

3.4.1.4 Communication networks

3.4.1.4.1 Ethiopia

According to MOARD (2009), PARC established a Core Communication Team (CCT) within the Ethiopian veterinary services to plan and undertake communication campaigns aimed at improving the participation of livestock owners and field personnel in achieving project goals. Four members of staff were trained in communication in Harare, Zimbabwe, during PARC

(Kariuki et al., 1999). The aim of the training was to upgrade the capacity of the Communication Unit to conduct multimedia campaigns and introduce PARC as a tool of collecting baseline data. The CCT conducted a number of community meetings using different communication tools and participatory approaches to raise awareness of livestock keepers and the general public about rinderpest control. The CCT is still operational and has been instrumental in linking livestock keepers with the formal veterinary personnel.

PACE developed an information management tool based on Oracle™ called the PACE Integrated Database (PID), which was launched at the end of October 2002. PID was later named Animal Resources Information System (ARIS) due to its capacity to manage various animal resources related data. The database was designed to store, transfer and analyze animal resources data and for sharing information. The objective for developing ARIS was to enable national animal health authorities make informed decisions, and to plan and organize rinderpest control programs based on availability of human and material resources. Due to software and other problems, the database is currently dysfunctional.

PACE also facilitated the training of staff on data management and Geographical Information Systems (GIS). Communication strategies were also developed and deployed in Ethiopia courtesy of PACE. As a result of these efforts, Ethiopia's data collection and reporting procedures were harmonized with those of international organizations.

3.4.1.4.2 Kenya

PACE Kenya established a Communication Unit at Kabete Vetlabs to sensitize and create awareness among the staff and the livestock community of rinderpest and other priority diseases such as HPAI, CBPP, RVF and Newcastle. The Unit uses various channels to disseminate information including radio, TV, newspapers, publications, skits and public meetings. The Communication Unit also works hand-in-hand with the DDCCs mentioned in section 3.4.1.3.2 above via established communication channels.

Like in Ethiopia, PACE developed and launched ARIS in Kenya to decentralize the national animal resources database to provincial level. ARIS captured information on animal health, production and economics. The system was used by the Department of Veterinary Services for generating disease reports for OIE, GIS reports and feedback field reports. The information was also used for informing disease control strategies. Since the expiry of PACE in 2004, the technical backstopping stopped and the Department experienced technical problems with ARIS which could not be sorted out. As a result ARIS is no longer in use.

3.4.1.5 Privatization of animal health services

3.4.1.5.1 Ethiopia

The third phase of PARC (PARC III) supported a program aimed at privatizing the Ethiopian veterinary services. A total of ECU 1.2 million was allocated to a Veterinary Privatization Scheme, a Veterinary Privatization Promotion Office and to support the Ethiopian Veterinary Association (MOARD, 2009). By 1997, ETB 798,195 in loans had approved for disbursement to 10 privatization candidates (Kariuki et al., 1999). PARC also supported the Animal Health Assistants and Animal Health Technicians Association and strengthened its organizations at the regional level. Additionally, community-based animal health workers (CBAHWs) were trained during PARC to carry out vaccination campaigns under the supervision of veterinarians, tailored to community needs. The Community-based Animal Health and Participatory Epidemiology (CAPE) Unit of the PACE project strengthened the CBAHW model through further training and provision of drug kits particularly in the lowland areas of Ethiopia. This paved way for the privatization of veterinary services in these areas.

3.4.1.5.2 Kenya

The PARC project set aside ECU 750,000 to support the Kenya Veterinary Association Privatization Scheme (KVAPS) in 1996. Since then, KVAPS has succeeded in financing over 50 new veterinary clinics in the high and medium agricultural potential areas. Over 100 veterinarians have benefited from its loan services[1]. In 2004, KVAPS became a fully fledged financial institution called the Kenya Livestock Finance Trust (KLIFT), which offers loans to all players in the livestock sector. Like in the case of Ethiopia, the CAPE Unit of PACE introduced the CBAHW model in ASALs to pave the way for the privatization of animal health services in those areas.

[1]http://klift.org/about.php

3.4.1.6 Emergency preparedness

3.4.1.6.1 Ethiopia

During PARC, a technical committee was established to develop a livestock early warning system (Kariuki et al., 1999). The committee developed the first draft of the contingency plan. Training was also conducted in most regions on emergency disease reporting. By the end of PARC, an emergency preparedness plan had been prepared and implemented (MOARD, 2009). Additionally, contingency plans were constructed and tested. These plans are currently being revised.

3.4.1.6.2 Kenya

During PARC, emergency preparedness plans were put in place by instituting the following measures (Kariuki et al., 1999):

- Creation of a quick response management team for the control of disease (especially rinderpest) outbreaks;
- Capacity strengthening in six regional (provincial) laboratories to carry out basic rinderpest diagnosis and epidemio-surveillance;
- Presence of a regional rinderpest reference laboratory [this status has since been lost] for advanced rinderpest diagnosis;
- Creation of a veterinary development fund to serve as a source of emergency financing;
- Having ready to use vaccination, camping, cold chain and communication equipment;
- Training of staff on rinderpest diagnosis, differential diagnosis, pathology and general disease epidemiology; and
- Establishment of a national animal disease emergency committee and emergency preparedness unit.

3.4.2 Farmers' perceptions of rinderpest eradication campaigns

3.4.2.1 Ethiopia

The five key informants from the livestock keeping community interviewed in Ethiopia had an average age of 66 years (range = 52 to 85 years). Of these, two were farmers, one was an artificial insemination service provider, and the other was previously a Kebele executive committee member while the other one was a community elder.

All the key informants had witnessed rinderpest outbreaks in their localities. They intimated that there were many rinderpest outbreaks during the Emperor Haile Selassie's era (1930 to 1974). During the outbreaks, the livestock keepers lost many cattle and some committed suicide due to the devastation that ensued.

Although the informants could not remember the rinderpest eradication projects by name, they could recall that vaccinations were carried out by vets who pitched tents in their villages and remained there until they vaccinated all the cattle.

The informants had a basic understanding of the signs/symptoms for rinderpest, judging from the answers they gave to the question: "name four main signs/symptoms of rinderpest in your cattle". None of the farmers had been involved in rinderpest search. Nevertheless, two informants had been involved in rinderpest reporting mainly by the Ministry of Agriculture officials (vets).

There is a well established disease reporting system in Ethiopia that starts with the farmer, who reports any notifiable disease in his herd (e.g. rinderpest, FMD, CBPP, blackquarter, anthrax, etc) to the Kebele authority (could either be a CBAHW or a Livestock Officer) at the village level who in turn reports to the Agricultural Office in the Kebele (if present) or Agricultural Office at the Woreda level. Woredas report to the Regional State office which eventually reports to the Federal Office.

3.4.2.2 Kenya

The 23 livestock keepers interviewed had an average age of 63.8 years (range = 47 to 80 years). Of these, 14 respondents (or 60.4%) were community elders, 3 (13%) were community religious leaders and the other 2 (8.7%) were brokers in the livestock market at Garissa. Of the remaining 3 respondents, one was a community development committee chairman, the other was a community development committee member and the last one was a school development committee member. In terms of education, 19 respondents (or 82.6%) had no formal education, 2 (8.7%) had completed *madrassa* while of the rest 2, one reached Standard 5 (basic education) while the other went up to Form One (secondary school).

Like their counterparts in Ethiopia, all the respondents in Garissa had considerable knowledge of rinderpest based on their ability to mention four main signs/symptoms of rinderpest, i.e., diarrhoea, lacrimation, fever and death within a short while (Table 28). These responses tally with the sign/symptoms given in USAHA (2008).

Table 28. Frequency of major rinderpest signs/symptoms mentioned by farmers in Garissa District, Kenya

	Responses	
Sign/Symptom	**n**	**%**
Diarrhoea	22	24.2
Lacrimation	21	23.1
Fever	19	20.9
Death within a week	8	8.8
Weight loss	5	5.5
Nasal discharge	5	5.5
Animal doesn't face wind	3	3.3
Change in coat color	3	3.3
Loss of hair	2	2.2
Blindness	1	1.1
Ribs are stuck in	1	1.1
Shivering	1	1.1
Total	**91**	**100**

Source: Farmer interviews

The respondents had witnessed rinderpest outbreaks in their localities between 1970 and 1992. The three most frequently reported years when rinderpest outbreaks are said to have occurred are 1979, 1980 and 1982 as reported by 2, 3 and 6 respondents, respectively.

Although the respondents could not tell the name of the rinderpest eradication campaigns, they could remember that at one time their vaccinated cattle were branded on the hump. At another time the vaccinated cattle had one of their ears notched while at some other time the vaccinated cattle had plastic ear-tags. These forms of identification of vaccinated cattle corresponded with JP15 (branding of the hump), PARC (ear-notching) and PACE (plastic ear-tags). Based on these forms of identification, only one respondent indicated he did not know about JP15. On the other hand, all the 23 respondents knew about PARC and PACE. Interestingly, none of the respondents knew about SERECU probably because there have not been any vaccinations done in Kenya since 2003.

Only two respondents had been involved in rinderpest search by the veterinary officers (they could not tell whether or not they were veterinary officers) while five others had ever reported rinderpest cases to the Veterinary Department. Nineteen respondents had reported various diseases to the Department 12 months prior to the interview. The frequency of the diseases reported is shown in Table 29.

Table 29. Frequency of livestock diseases reported to the Veterinary Department by respondents 12 months prior to the survey

	Responses	
Disease	**n**	**%**
CBPP	10	24.4
CCPP	9	22.0
FMD	8	19.5
Trypanosomosis	7	17.1
LSD	3	7.3
Anthrax	2	4.9
3-day sickness	1	2.4
Blackquarter	1	2.4
Total	**41**	**100**

Source: Key informant interviews

3.5 Impacts of rinderpest eradication on food security

3.5.1 Impacts on food security in Ethiopia

According to the livestock keepers interviewed, rinderpest eradication has extinguished the incessant problem of massive livestock deaths that they witnessed when they were young. One informant reported that their animals are now healthy and the farmers are producing more crops [using animal traction] and realizing increased incomes. Another informant said that they are now selling more animals and there are no quarantines due to rinderpest. Yet another said "our animals are healthy. As we plough using animals, their existence is crucial for us to survive, to produce any agricultural product".

Another farmer said that rinderpest eradication is important both at the country and farmers' level because without livestock, most of the farmers would be unable to produce anything since they use oxen to plough their farmland.

3.5.2 Impacts on food security in Kenya

Table 30 presents farmers' perceptions of the benefits of rinderpest eradication in Kenya. The three main benefits mentioned by farmers were market (mentioned in 22% of the cases), more milk (14%) and more cash (13%). These benefits revolve around household food security. The respondents indicated that rinderpest led to prolonged market closures which curtailed local trade in livestock. In areas where residents depend solely on livestock for their livelihood such as Garissa, market closure erodes people's capacity to earn and therefore constrains their ability to purchase food.

Table 30. Farmers' perceptions of benefits of rinderpest eradication in Kenya

Perceived benefit	Responses	
	n	**%**
Increased market access	19	22.1
More milk	12	14.0
More cash	11	13.0
Healthy cattle	8	9.3
Free movement	6	7.0
More cattle	5	5.8
More production	4	4.7
More meat	4	4.7
Fat cattle	3	3.5
More knowledge on rinderpest	2	2.3
Free vaccination	2	2.3
More sales	2	2.3
More ghee	2	2.3
Higher productivity	2	2.3
Better prices	2	2.3
Reduced mortality	1	1.2
Mixing of livestock	1	1.2
Total	**86**	**100**

Source: Farmer interviews

3.6 Impacts of rinderpest eradication on trade

3.6.1 Impacts on livestock trade in Ethiopia

Although rinderpest has been eradicated in Ethiopia, bans on trade in livestock and livestock products from Ethiopia are still in place because Ethiopia is still endemic to a number of trade-sensitive trans-boundary animal diseases (TADs) and notably FMD. Besides, the endemicity of TADs within the Somali Ecosystem has made it difficult for Ethiopia to negotiate with potential importers (e.g. Gulf countries) for the lifting of trade bans on Ethiopian livestock and livestock products. It seems, therefore, that the opening up of the export market for Ethiopian livestock and livestock products will require the control and/or eradication of major trade limiting TADs and not just the eradication of rinderpest alone. Nevertheless, local trade in livestock has thrived due to increased cattle population, reduced number of quarantines and free movement of livestock to markets and in search of pasture.

3.6.2 Impacts on livestock trade in Kenya

As shown in Table 30, one of the benefits of rinderpest eradication was increased access to livestock markets. Therefore, since the eradication of rinderpest in Kenya, the local trade in livestock and livestock products has flourished, with farmers reporting more healthy cattle which fetch higher market prices.

With regard to international trade in livestock and livestock products, Kenya's potential is hardly exploited due to the presence of TADs (Aklilu, 2002). Like in the case of Ethiopia, Kenya's livestock products remain banned by potential importers in the European Union and Gulf States, principally due to FMD and RVF (Irungu et al., 2009). However, since 2003, Kenya has been able to negotiate with Mauritius to export live animals (Figure 5) in spite of the presence of TADs. Control and eventual eradication of TADs will hopefully expand export trade in livestock and livestock products from Kenya.

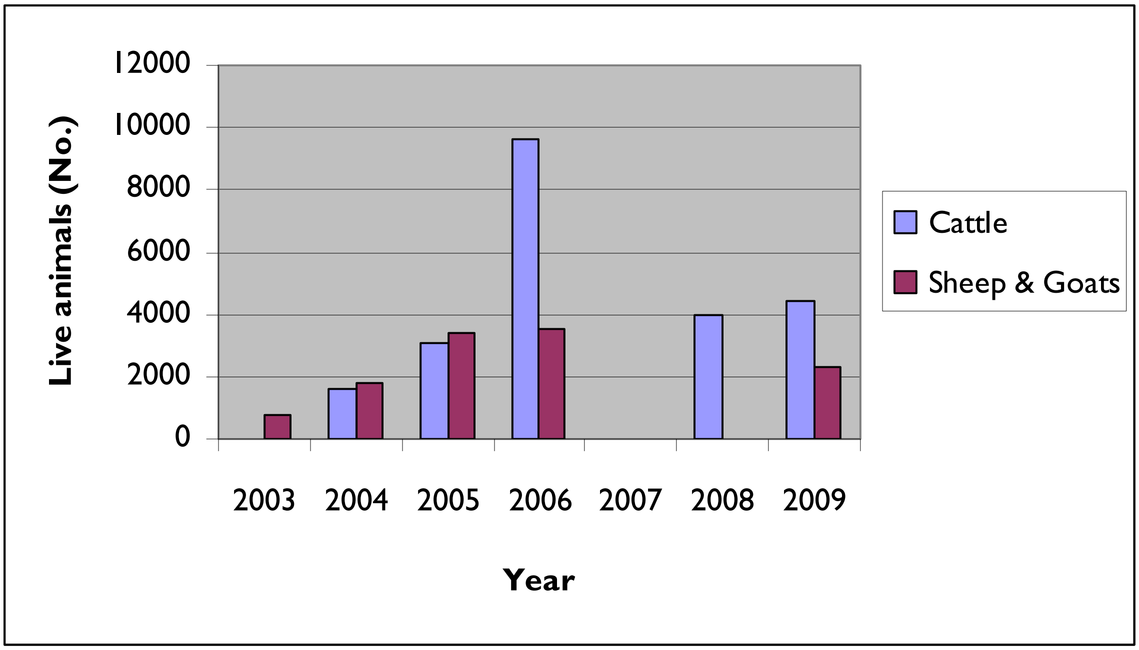

Figure 5. Number of livestock exported to Mauritius (2003-2009)

Source: Irungu et al. (2009)

3.7 Benefits at the AU-IBAR level

Rinderpest eradication in Africa was initially spearheaded OAU-IBAR and then by its successor the AU-IBAR. Indeed, the Bureau was established in 1950 with the sole purpose of eradicating rinderpest from Africa. Although its mandate has since expanded to cover major transboundary diseases, the eradication of rinderpest from Africa as indicated by progress made by different countries along the OIE pathway is one of the major benefits attributable to AU-IBAR. Other benefits include:

- Establishment of an Epidemiology and Data Management units within AU-IBAR in 1999 during PACE. This triggered the establishment of epidemiology and data management units in all the 30 participating countries, which spearheaded rinderpest surveillance and vaccination. The epidemiology unit at AU-IBAR also hosted wildlife specialists for the East African region and a laboratory expert seconded to PACE by the International Atomic Energy Agency (IAEA).
- Establishment of a wide network and goodwill of governments (especially veterinary departments and research institutes), the private sector, civil society and donors that

contributed toward the eradication of rinderpest from Africa. This network can be used to control and eventually eradicate other major TADs such as FMD, CBPP, HPAI, RVF and PPR, that continue to inhibit livestock trade in Africa

- Capacity building within the AU-IBAR itself. For instance, PACE established an Information and Communication System (ICS) in AU-IBAR to improve the access and sharing of information with member countries and with other international institutions. It also established and maintained a LAN with an e-mail system and mailing lists in IBAR. In addition, some staff in AU-IBAR have been trained in various skills such as data management, project management and monitoring and evaluation through the capacity building component of different rinderpest eradication campaigns.
- At the regional coordination for West and Central Africa, PACE build the technical and managerial capacity.
- Establishment of the Pan African Veterinary Vaccine Centre (PANVAC) which facilitated training for veterinarians and laboratory personnel (see Appendix I).
- PACE also established a rinderpest vaccine bank as a precaution against a re-emergence of the disease. A vaccine stock of 500,000 doses is currently held at the Botswana Vaccine Institute.
- The knowledge and experience acquired from the rinderpest eradication exercise within AU-IBAR is invaluable in contributing expertise in future endeavors of a similar nature.

4. Synthesis of Results

4.1 Introduction

The eradication of rinderpest from Africa is unprecedented in history. It marks the first time ever that an animal disease has been wiped off the face of the earth, and the second time after smallpox that a disease has been consigned to the dustbins of history as a result of human effort. We are therefore at an exciting juncture in the course of human history. This achievement would not have been realized were it not for the strong commitment of national governments, regional organizations such as AU-IBAR, and development partners, particularly EU, who invested huge amounts of financial resources towards rinderpest eradication.

As Africa, and indeed the rest of the world, celebrates the unprecedented achievement, the three key questions that beg for answers are (i) how well did the rinderpest eradication exercise utilize the huge public resources invested? (ii) what lessons can stakeholders draw from the rinderpest eradication exercise? (iii) what next after rinderpest eradication?

4.2 Effectiveness of public resources invested in rinderpest eradication

To answer the first question, an *ex post* social cost-benefit analytical framework was used in the present study. Three financial measures were used, namely, net present value (NPV), benefit-cost ratio (BCR) and internal rate of return (IRR), constitute what is called capital budgeting decision tools. Each of these measures provides different pieces of information and decision-support tools to help decision makers gauge whether or not a particular project is/was worth undertaking. Recent studies indicate that capital budgeting is becoming increasingly important in decision making because of the need for more efficient spending of public funds (Boardman et al., 2001).

For starters, the net present value (NPV) provides a basis on which to determine whether the benefits realized from a project cover the cost of investment. In this study, all the four projects (JP15, PARC, PACE and SERECU) registered high and positive NPVs. Tambi et al. (1999) also found high and positive NPVs for the PARC project in 10 countries, with Ethiopia and Kenya having ECU 14.3 million and ECU 0.6 million respectively. For public projects such as those evaluated in this study, the positivity of the NPV guarantees that those who gain from the project can potentially compensate those who lose from it and still remain better off.

The benefit-cost ratio (BCR) provides a measure of the efficiency with which limited funds are utilized to generate realized benefits. It therefore provides a good indicator for comparing the profitability of the eradication investments made across countries with varying scales of intervention. The results show that all the four rinderpest eradication projects in Ethiopia and Kenya had BCRs greater than one. Although the BCRs found in this study were somewhat greater than those reported by Tambi et al. (1999) for the PARC project in 10 African countries, their ratios were also greater than unity but lower than those reported by Felton and Ellis for rinderpest control in Nigeria in the 1960s. This suggests that the financial measures used to compare benefits and costs are sensitive to the assumptions made on various parameters such as prices, quantities of products and the time horizon. Lack of consistent price and quantity data in many African countries compromises the ability to replicate the results obtained in different studies. Nevertheless, the fact that the BCRs found in this study were greater than unity implies that rinderpest eradication from Ethiopia and Kenya was economically profitable. In both countries, JP15 was the most profitable investment followed by SERECU-Ethiopia and PACE-Kenya.

The returns to an investment can be measured as an interest rate called the internal rate of return (IRR). The comparison of this interest rate to prevailing interest rates e.g. for an income-earning security such as the risk-free treasury bill or Treasury bond enables the analyst to assess the opportunity cost of the money invested in the project. Hence, internal rates of returns that are higher than the Treasury bill or bond interest rate are more preferred. It is worth noting that the IRR is sensitive to the duration of the project; shorter periods make it infeasible to compute IRR because cash inflows do not have adequate time to accrue. Except for PACE-Ethiopia which had an IRR lower than the 3% annual commercial bank interest rate on deposits, all the other projects had substantial returns on investment. In particular, JP15-Kenya had the highest IRR of 38.4% followed by PARC-Ethiopia with 33.8%. Tambi et al. (1991) found internal rates of return varying from 11% for Côte d'Ivoire, 23% for Ethiopia to 118% for

Burkina Faso. The high IRRs suggest that except PACE-Ethiopia, the returns of the other projects were well above the opportunity cost of capital.

All in all, three projects in Ethiopia (JP15, PARC & SERECU) and all the four projects in Kenya generated sufficient benefits that covered the funds invested and realized higher returns than alternative investments. Therefore, stakeholders (the livestock communities, governments, regional organizations and development partners) should rest assured that the scarce public funds invested in rinderpest eradication projects were well used. Moreover, the positivity of the net present values for all the rinderpest eradication projects evaluated in this study is an indicator of the achievement of net social welfare benefits for the citizens of Ethiopia and Kenya.

4.3 Lessons learned

The second question relates to the lessons that can be drawn by stakeholders from the rinderpest eradication exercise. Africa, and indeed the rest of the world, is still threatened by many animal diseases. Taking stock of the knowledge accumulated and experiences gained from rinderpest eradication could therefore be beneficial to stakeholders in the livestock industry as they prepare to tackle the next disease. The main lessons to be learned include, *inter alia*:

(i) That for any disease eradication exercise to succeed; there is need for unbridled political goodwill. For instance, national governments were highly committed to rinderpest eradication campaigns with some like Benin, Burkina Faso, Mali and Tanzania contributing over 50% of the total cost of PARC.

(ii) The role of the donor community in catalyzing rinderpest eradication campaigns through provision of requisite funding is critical. For example, in the case of rinderpest eradication, the EU contributed about 56% of the PARC's costs and therefore helped to initiate the campaign even in countries where counterpart funding was not immediately forthcoming.

(iii) Owing to budgetary constraints facing many African countries, mass vaccination of animals (where necessary) *a la* JP15 may not be financially viable. Experience from rinderpest eradication shows that focused strategic vaccination (immuno-sterilization) based on rigorous epidemiological surveillance and risk analysis, *a la* PACE and SERECU, not only reduces wastage of scarce public funds but also speeds up the process of disease eradication.

(iv) An effective disease epidemiosurveillance system at the country level requires availability of both human and physical resources (e.g., office equipment, vehicles, laboratories, camping equipment and cold chains). African countries must redouble their efforts to ensure that such capacity is not only built but also is maintained.

(v) An effective disease reporting/early warning system that incorporates all stakeholders (from grassroots communities to the national and regional veterinary personnel) is necessary to ensure early detection and rapid stamping out of any future incursion. Sustained funding for such systems is critical.

(vi) Disease control/eradication can be achieved only in an environment of peace and security. African countries must therefore foster peace and security both within and outside their national borders.

(vii) Good veterinary governance is a must, i.e., in each country, there is need for a national veterinary service with clear mandate and roles backed up by appropriate legislation / able to act and react within an effective, structured national legislative framework, and be provided with the appropriate financial and human resources to enforce it.

(viii) Tackling one disease as was the case with rinderpest is not attractive to livestock owners and may not be the best option from an economic point of view.

(ix) The void left by rinderpest among the morbile viruses – and the fact that PPR should ideally have been tackled concurrently with RP – there is need to address PPR control/ eradication.

4.4 Way forward

The fact that rinderpest is almost eradicated from Africa is not a justification for continent and the rest of the world to sit on its laurels. If the experience of JP15 is anything to go by, complacency can have far-reaching consequences. Therefore, Africa should exercise vigilance even after rinderpest is eradicated from the continent because (i) there is the possibility that the rinderpest virus may persist in a cryptic form particularly in the East African region which hosts over 60% of Africa's livestock and a significant population of wild game. For instance, the detection of Lineage 2 rinderpest virus in Kenya in 1994 after 30 years of absence shows that rinderpest virus can hibernate for a long period of time; (ii) the virus may escape from laboratory stores due to weak biosecurity systems in Africa leading to re-emergence of the disease, and (iii) there is also the possibility that new rinderpest-like diseases may emerge from mutated morbiliviruses. Such diseases may have a wider host range, including humans.

In order to contain the virus and to ensure permanent disease free status, Africa must maintain the level of awareness of rinderpest and sustain its surveillance. Sadly though, Africa, especially the East African region, is ill-equipped to expeditiously extinguish a rinderpest incursion should one occur due to budgetary constraints and inadequate human and physical resources. The persistent civil war in Somalia coupled with political instability in the Africa Horn and the Great Lakes region, does not augur well for staging a well-coordinated and focused regional approach against emergencies, let alone emerging animal diseases. Given that rinderpest is a transboundary animal disease (TAD), a regional surveillance approach should be promoted and strengthened through regional cooperation and mutual assistance. In this regard, AU-IBAR should strengthen its relationship with other regional organizations and stakeholders like the Inter-Governmental Authority on Development (IGAD), the Common Market for Eastern and Southern Africa (COMESA) and the East African Community (EAC) so as to mainstream transboundary animal health issues into their programs. On the other hand, bearing in mind the enormity of investments made to achieve the gains made so far and aware of the repercussions of failing to maintain an effective disease surveillance system, it is in the interest of the AU-IBAR and the donor community to continue assisting East African countries to maintain and sustain a coordinated long term regional rinderpest epidemio-surveillance system, both in livestock and wildlife.

The fact that rinderpest is almost eradicated from Ethiopia and Kenya has not significantly improved these countries' export of livestock and livestock products. This is because TADs particularly FMD, RVF, PPR, African Swine Fever (ASF) and CBPP, are still rampant in these countries. WTO's SPS agreement requires that exports of animals and products be free from disease and that the country or zone of origin be disease free, not only through lack of diagnosis of the disease but also through the negative results of auditable surveillance data. For Ethiopia and Kenya, this means that considerable investment is needed to stamp out TADs from these countries in order to fully exploit their export potential. A key starting point would be to institute an effective syndromic surveillance of TADs. Such a system should link key stakeholders for the exchange of disease information and for expeditious emergency response. The syndromic surveillance program should pay special attention to regions of Africa most recently infected with rinderpest. Of particular importance is the Afar region of Ethiopia, southern Sudan and Somalia, which are characterized by poor infrastructure, civil strife and weak animal health delivery systems. This will require an effective veterinary service in each country with a clear mandate and roles backed up by appropriate legislation to enable it to act and react within an effective, structured national legislative framework. Therefore AU-IBAR and its partners should consider helping build the human resource capacity of veterinary departments in Ethiopia and Kenya particularly in areas of disease diagnosis and epidemiology. Besides this, concomitant investment in physical infrastructure (laboratories, vehicles and office equipment) will be needed.

Whereas it may be socially desirable to stamp out all TADs from an entire country or region within a country, the economics of doing so may be prohibitive, given the budget constraints facing many countries including Ethiopia and Kenya. Nevertheless, investment could be made on a zonal basis, such as in the case of the increasingly popular "disease-free zones". This approach will ensure that disease is consistently and systematically controlled from an identified zone and then scaling up to the whole country. Kenya is in the process of implementing disease free zones. However, the implementation of such programs should be informed by adequate veterinary, social and economics research. Additionally, it should be preceded by the adoption of the necessary legal, policy and institutional frameworks. Tackling multiple TADs simultaneously may benefit from scale economies.

It is well known that Africa, like the rest of the world, is experiencing changes of its ecosystem due to population growth, climate change, economic development and movement of goods and people. These changes pose new threats of emerging and re-emerging infectious diseases that affect animal and human populations. Funds should therefore be set aside to study, monitor and control some of these events to reduce vulnerability and risk of disease outbreaks in the African continent. Unfortunately, many African governments are facing major economic and financial problems and are finding it difficult to adequately fund veterinary services. The challenge for

AU-IBAR and its partners is help African governments to identify alternative ways of funding their animal health systems on a sustainable basis. A starting point would be to cut spending on non-growth promoting activities such as the military. Partnership with development partners should be maintained and strengthened. Additionally, trade expansion through regional economic integration could provide the much needed fiscal resources for disease control.

Finally, The African Union should continue playing its coordinating and advocacy roles. In particular, AU will be important in lobbying governments and the donor community to commit more financial resources for the development of livestock in Africa. As the experience of rinderpest eradication shows, good political governance is a necessary condition for disease control/eradication as it not only guarantees good veterinary governance but also fosters peace and security. It is worth noting that the last rinderpest foci were in conflict areas of Afar region of Ethiopia, southern Sudan and Somalia. Therefore, African countries in cahoots with the AU, must rise to the occasion and embrace peace, regional integration and cross-border cooperation if the war against poverty is to be won in like manner that rinderpest has been eradicated.

5. Conclusions

This study sought to evaluate the costs and benefits of rinderpest eradication from Ethiopia and Kenya. The study used primary data collected through interviews with key informants in Ethiopia and Kenya. Secondary data were also used. In particular, FAOSTAT (2010) cattle population data were used due to lack of consistent country level series covering the study period (1968-2008). Due to the aggregated nature of FAOSTAT data, it was imperative to make assumptions on the data to facilitate the computation of benefits of rinderpest eradication. As far as possible such assumptions were backed up by relevant literature. The costs and benefits of rinderpest eradication were evaluated under a social cost-benefit framework.

The study made the following key findings:

- The total benefits of rinderpest eradication from Ethiopia and Kenya were US$ 951.3 million and US$ 433.97 million respectively. In Ethiopia, the largest proportion of these benefits (65%) was contributed by PARC through gains from beef production. In Kenya, the largest proportion of the benefits (43.7%) came from PACE, mainly due to its effect on milk production.
- In both countries the NPVs were large and positive indicating that rinderpest eradication generated substantial returns to both economies.
- Likewise, the BCRs were also greater than unity suggesting that the money invested in rinderpest eradication in Ethiopia and Kenya was effectively used.
- On the other hand, Ethiopia's JP15, PARC and SERECU had IRRs that were comparatively higher than the current interest rate of 3% per annum on deposits offered by the Commercial Bank of Ethiopia. PACE-Ethiopia's IRR was only 2.6% suggesting that it did not yield sufficient returns to cover the cost of invested capital. In Kenya, the IRRs were fairly higher than the 7.4% return on the risk-free 91-day Treasury Bill offered by the Central Bank of Kenya in 2009. PARC and PACE had only marginal returns on investment of 11.9% and 8.6% respectively.
- Overall, rinderpest eradication contributed 2.4% and 0.5% to the Ethiopia's and Kenya's economies respectively. PARC-Ethiopia had the highest contribution (of 1.5%) to Ethiopia's economy while PACE-Kenya had the highest contribution (of 0.18%) to Kenya's economy.

- Rinderpest eradication expanded the final demand for livestock products in the rest of the economy. In Ethiopia, this amounted to US$ 457,594.8 while in Kenya the final demand expanded by US$ 231,379.3. Rinderpest eradication also increased the household incomes of livestock keepers in Ethiopia and Kenya by US$ 366,352.3 and US$ 2,822.8 respectively.
- The indirect benefits of rinderpest eradication include:
    - Capacity building, e.g., 10 veterinarians in Ethiopia were trained to MSc level courtesy of PARC-Ethiopia. Numerous other staff in Ethiopia and Kenya attended short-term training in various fields during the rinderpest eradication campaign.
    - Equipment of laboratories – many laboratories obtained materials and equipment during the rinderpest eradication campaign. However, none of the laboratories in Ethiopia and Kenya has international accreditation.
    - Disease surveillance methodologies e.g. participatory epidemiology and participatory disease search were developed and implemented in Ethiopia and Kenya during the rinderpest eradication campaigns. These methodologies are still being used for the surveillance of such diseases as FMD, CBPP, RVF, HPAI and PPR.
    - Elaborate communication networks have been established linking livestock keepers with the veterinary department. These networks are currently being used to report other diseases such as FMD, anthrax and CBPP. Since their creation, the networks have greatly enhanced disease reporting in both countries.
    - Although the privatization of veterinary services did not pick up in Ethiopia as envisaged under PARC, in Kenya, it saw the establishment of over 50 private veterinary clinics in high and medium agricultural potential areas. In the arid and semi-arid areas, the community-based animal health worker (CBAHW) model paved way for the privatization of animal health services in those areas.
    - According to the key informants from the farming community, the eradication of rinderpest from both Ethiopia and Kenya has led to improved food security because:
        - There no more rinderpest-related quarantines
        - Their animals are more healthy and therefore more productive

        - Their animals fetched better market prices that during the time of rinderpest outbreaks
        - Animals have more freedom to mix and to move across geographical areas in search of pasture and water.
    - Although rinderpest eradication has increased domestic trade in livestock and livestock products in Ethiopia and Kenya, external trade in livestock and livestock products in the two countries still remains unexploited largely due to the presence of other trans-boundary diseases (TADs) such as FMD and CBPP. These TADs still constrain livestock exports from the two countries.
    - AU-IBAR benefited from rinderpest eradication through
        - The fulfillment of its mandate (of eradicating rinderpest from Africa)
        - Capacity-building of human resources, facilities and equipment within AU-IBAR
        - Establishment of Epidemiology Units in various countries to coordinate disease surveillance and vaccination
        - Creation of a wide network and goodwill of governments, the private sector, civil society and donors that contributed toward the eradication of rinderpest from Africa. This network can be used as a platform for galvanizing support in future disease control/eradication initiatives
        - Lessons and knowledge acquired from rinderpest eradication which could be used in the control and/or eradication of other livestock diseases in future.

The following are the recommendations of the study:

1. Although rinderpest is eradicated, Africa should remain vigilant against possible future re-emergence of rinderpest. In this regard, all the rinderpest virus strains held in laboratories in Africa should either be destroyed or kept in high bio-security facilities to reduce the chances of the virus escaping. In the meantime, African states should put in place contingency plans to deal with possible future re-emergence of rinderpest.
2. Given that TADs are still rampant in Africa, there is need to establish an effective syndromic surveillance system for TADs. Such a system should link key stakeholders for the exchange

of disease information and for expeditious emergency response. The syndromic surveillance program should be mainstreamed in the AU-IBAR CAADP framework.

3. It is well known that many African countries are currently facing financial constraints due in part to the current global financial meltdown and partly due to rapidly growing human population. At the same time, donor funding has increasingly diminished in recent years. Therefore, African countries should come up with innovative ways to sustainably fund animal health services. A starting point would be to cut spending on non-growth promoting activities such as the military. Partnership with development partners should be maintained and strengthened. Additionally, trade expansion through regional economic integration could provide the much needed fiscal resources for disease control.
4. The African Union should continue playing its coordinating and advocacy roles. In particular, AU will be important in lobbying governments and the donor community to commit more financial resources for the development of livestock in Africa.

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Appendices

Appendix I: List of workshops facilitated by PANVAC during PARC & PACE

Workshop	Dates	Location	Number of trainees	Level of trainees	Beneficiaries
Rinderpest diagnosis and vaccine production	2-5 May 1988	Laboratoire national de l'elevage et de recherches veterinaries (LNERV), Dakar, Senegal	6	Veterinarians & technicians	Mali, Chad, Cameroo, Cote d'Ivoire, Niger, Senegal
Rinderpest vaccine production & quality control	20-25 June 1988	National Veterinary Institute, Debre Zeit, Ethiopia	7	Veterinarians	Botswana, Ethiopia, Kenya, Nigeria, Somalia, Sudan
Avian viral disease vaccine production	12-14 July 1988	Laboratoire de Pathologie Animale (LPA), Bingerville, Cote d'Ivoire	8	Veterinarians & technicians	Senegal, Guinea, Mali, Niger, Cote d'Ivoire, Chad, Cameroon, Zaire
Rift Valley fever (RVF): epidemiology, diagnosis, control & prevention	12-15 July 1988	WHO Regional Office in Mali	24	Veterinarians & Physicians	Mali, Senegal, Niger, Mauritania, Gambia

Contagious bovine pleuropneumonia (CBPP) vaccine production	19-23 Sept 1988	Central Veterinary Laboratory (CVL), Mali	7	Veterinarians & technicians	Senegal, Guinea, Mali, Niger, Cote d'Ivoire, Chad, Cameroon
Seminar on vaccine quality control	5-12 Dec 1988	National Veterinary Institute, Debre Zeit, Ethiopia	8	Government officials from Ministry of Agriculture	Ethiopia, Ghana, Malawi, Mozambique, Nigeria, Sudan, Zambia
Bacterial vaccines (pasteurellosis, brucellosis, anthrax, clostridia)	6-11 Feb. 1989	National Veterinary Institute, Debre Zeit, Ethiopia	4	Veterinarians	Ethiopia, Nigeria, Tanzania, Somalia
Production & quality control of bacterial vaccines	13-19 Mar 1989	National Veterinary Institute, Debre Zeit, Ethiopia	4	Veterinarians	African countries
Newcastle disease & other avian veterinary vaccines	3-8 Apr. 1989	National Veterinary Institute, Debre Zeit, Ethiopia	6	Veterinarians	Ethiopia, Kenya, Lesotho, Mozambique, Sudan, Uganda
Production et	22-26 May	Laboratoire	9	Veterinarians	Cameroon,

controle de quality des vaccines bacteriens	1989	national veterinaire, Garoua, Cameroon			Niger, Cote d'Ivoire, Mali, Senegal, Guinea, Madagascar, Zaire, Rwanda
Advanced techniques of rinderpest vaccine quality control	22-27 May 1989	National Veterinary Institute, Debre Zeit, Ethiopia	6	Veterinarians	Ethiopia, Kenya, Mozambique, Nigeria, Somalia, Sudan
Production et controle de qualite des vaccine aviaires a virus	18-22 Sept. 1989	Laboratoire national veterinaire, Garoua, Cameroon	10	Veterinarians	Cameroon, Cote d'Ivoire, Guinea, Madagascar, Mali, Niger, Rwanda, Senegal, Zaire
Poultry vaccines	14-19 Oct. 1989	Animal Research Administration El Amarat, Khartoum, Sudan	10	Veterinarians	Ethiopia, Kenya, Lesotho, Mozambique, Nigeria, Somalia, Sudan, Rwanda, Turkey
Epidemiologie et serosurvelance	23-31 Oct. 1989	Laboratoire nationale de	9	Veterinarians	Senegal, Mali, Guinea, Cote

de la pest bovine		l'elevage et de recherches veterinaires, Dakar, Senegal			d'Ivoire, Niger, Cameroon, Zaire, Madagascar
Advanced production of rinderpest vaccine	13-18 Nov. 1989	National Veterinary Institute, Debre Zeit, Ethiopia	6	Veterinarians	African & Near East countries
Mycoplasmes et peripneumonie	20-24 Nov. 1989	Laboratoire nationale de l'elevage et de recherches veterinaires, Dakar, Senegal	9	Veterinarians	Senegal, Mali, Cote d'Ivoire, Niger, Chad, Cameroon, Zaire, Madagascar, Rwanda
Freeze-drying process	11-16 Dec 1989	National Veterinary Institute, Debre Zeit, Ethiopia	20	Veterinarians, senior technicians, free-drying technologists	Botswana, Cameroon, Chad, Ethiopia, Guinea, Kenya, Mali, Lesotho, Madagascar, Mozambique, Niger, Nigeria, Rwanda, Senegal, Somalia,

					Sudan, Uganda, Zambia, Afghanistan, Egypt, Turkey, Jordan
Production & quality control of mycoplasmal vaccines	12-16 Nov. 1990	Laboratoire Central Veterinaire, Bamako, Mali	21	Veterinarians	Angola, Botswana, Cameroon, Chad, Ethiopia, Kenya, Lesotho, Malawi, Mali, Mozambique, Nigeria, Senegal, Tanzania, Zambia
Newcastle disease for rural Africa	22-26 April 1991	National Veterinary Institute, Debre Zeit, Ethiopia	26	Veterinarians	Angola, Bostwana, Cameroon, Chad, Cote d'Ivoire, Ethiopia, Guinea, Kenya, Lesotho, Madagascar, Malawi, Mali,

					Mozambique, Niger, Nigeria, Rwanda, Senegal, Sudan, Tanzania Uganda, Zaire, Zambia
Regional meeting I: Meeting of Directors of National Veterinary Vaccine laboratories in Africa	27-28 Sept. 1990	Nairobi, Kenya	18	Directors of National Veterinary Vaccine laboratories	Angola, Botswana, Cameroon, Chad, Cote d'Ivoire, Ethiopia, Guinea, Kenya, Lesotho, Malawi, Mozambique, Nigeria, Rwanda, Senegal, Somalia, Tanzania, Zaire, Zambia
Regional meeting I: Meeting of Directors of National Veterinary	6-8 July 1992	Dakar, Senegal	20	Directors of National Veterinary Vaccine laboratories	Angola, Botswana, Cameroon, Chad, Ethiopia,

Vaccine laboratories in Africa					Guinea, Kenya, Lesotho, Madagascar, Malawi, Mali, Mozambique, Nigeria, Rwanda, Senegal, Sudan, Tanzania, Uganda, Zaire, Zambia

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