AN ECONOMIC EVALUATION OF THE IMPACT OF THE PRIVATISATION POLICY ON ANIMAL HEALTH DELIVERY SERVICES IN AFRICA: A CASE STUDY OF ZIMBABWE

BY

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DEDICATION

To the three people that mean so much to me: Seun my son, Sade my daughter and Ayo my wife!

DECLARATION

I hereby declare that the contents of this thesis are composed by me except otherwise specifically stated.

ABSTRACT

In many countries in Africa, the delivery of animal health services, especially in rural areas, is far from adequate. These services therefore need restructuring. An analysis of these systems indicates that the development of an appropriate analytical framework for evaluating them would prove to be extremely valuable. Such a framework should be able to identify, qualify and quantify, the various segments of the population, their spatial distribution, and specific health care needs, as well as permit the prediction and evaluation of the socio-economic impact of policies and interventions on the delivery system.

In order to develop such a framework, a project was undertaken using the concept of Precision Service Delivery (PSD), with the objective of developing a robust analytical framework which is universally applicable to all health care delivery systems. PSD is aimed at adjusting and "fine-tuning" the delivery of services, so as to meet the specific health care needs of the different segments of the population, in the context of their geographical location. The animal health care delivery system in Zimbabwe was used as a case study. The PSD framework was used in this study, to analyse the economic and social impact of different scenarios of the current privatisation oriented policy reforms. This involved the use of statistical techniques, a geo-spatial modelling technique and Linear Programming mathematical models.

A questionnaire survey of 145 livestock producers was conducted with representation from all four livestock production systems in Zimbabwe. The objective was to evaluate the socio-economic and health care variables that characterise the production systems. From fourteen putative variables identified, eight were extracted using Principal Component Analysis, as a bases for characterising the existing livestock production systems. Using Multiple Discriminant Analysis, the validity of the different production systems as distinct classes was confirmed.

A modified Contingent Valuation Method (CVM) was used to quantify both the existing and latent demand for privatised animal health services in Zimbabwe. Various possible scenarios for the delivery of animal health care services were modelled using the Linear Programming technique. These exercises permitted the evaluation of the role of different cadres of professionals in a privatised delivery system. The impact of withdrawal of subsidy as in privatisation was also modelled. The results suggest that, latent demand for animal health services post privatisation exceeds current level of veterinary uptake. Geo-spatial modelling techniques permitted the comparison of equity of access to animal health services among the different production systems. It emerged that non-commercial producers have less access to health care services than their commercial counterparts. Furthermore, the lower income householders in Harare have less access to small animal clinical facilities than higher income householders.

From the results of these studies, it is concluded that:

- Livestock producers in Zimbabwe are best categorised as either commercial or non-commercial producers. However, the dimensions which are useful in distinguishing the different production systems are not significant in predicting their uptake of animal health services.
- Privatisation policy reforms would have a major impact on the delivery of animal health services in Zimbabwe. The impact may be positive or negative depending on the appropriateness of the privatisation initiative being implemented.
- There is a difference in the extent of the impact of the privatisation policy on various livestock producer groups, with the non-commercial producers being most affected. In the worst case scenario such as the withdrawal of all subsidies and the abscence of paraveterinarians, non-commercial livestock producers may not receive any services from self-sustaining professional private practitioners.
- Consequently, different models of service delivery would be required to provide an optimum level of health care service for the different livestock producer groups in the country.

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TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ABU	Ahmadu Bello University, Zaria Nigeria
AEU	Animal Economic Unit
AHMC	Animal Health Management Centres
AHYB	Animal Health Year Book
ANON	Anonymous
ANOVA	Analysis of Variance
ARF	Agricultural Research Foundation
CBA	Cost Benefit Analysis
CBPP	Contagious Bovine Pleuropneumonia
CBR	Cost-Based Reimbursements
CEA	Cost-Effectiveness Analysis
CSO	Central Statistical Office
CTA	Technical Centre for Agricultural and Rural Co-operation
CTVM	Centre for Tropical Veterinary Medicine
CUA	Cost-Utility Analysis
CV(M)	Contingent Valuation Method
DSE	German Foundation for International Development
DVS	Department of Veterinary Medicine
ECF	European Community Funds
ECU	European Currency Unit
EMS	Emergency Medical Services
ESAP	Economic Structural Adjustment
FAO	Food and Agricultural Organisation
FMD	Foot and Mouth Disease

GFA	Gessellschaft Fur Agraprojecte in Ubersee
GIS	Geographical Information System
GOZ	Government of Zimbabwe
GPS	Geographical Positioning System
GRAFLOC	Graphical Location-Allocation Model
GUI	Graphical User Interface
HCDS	Health Care Delivery Services (Systems)
HIVSS	Highlands and Islands Veterinary Services Scheme
ICA	Intensive Conservation Area
IFPRI	International Food Policy Research Institute
ILCA	International Livestock Centre for Africa
KMO	Kaiser-Meyer-Olkin Test
L-A	Location-Allocation Model
LAP	Large Animal Practice
LOCHWISP	Location of Centres Heuristic With Iterative Search on a Plane
L-P	Linear Programming
LU	Livestock Unit
LVI	Local Veterinary Inspectors
MDA	Multiple Discriminant Analysis
MRA	Multiple Regression Analysis
MSA	Measure of Sampling Adequacy
MTD	Mean Travel Distance
OIE	International Office of Epizootic
PARC	Pan-African Rinderpest Campaign
PC	Personal Computer
PC(A)	Principal Component Analysis

PSD	Precision Service Delivery
PVI	Practice Viability Index
PVO	Principal Veterinary Office(r)
QALY	Quality-Adjusted-Life-Years
SAP	Small Animal Practice
SG	Standard Gamble Technique
SPCA	Society for the Protection of Cruelty to Animals
TLU	Tropical Livestock Unit
TTO	Time Trade-Off Technique
VC	Veterinary (Viability) Coefficient
VEO	Veterinary Extension Officer
VEU	Veterinary Economic Unit
WHO	World Health Organisation
WTP	Willingness-To-Pay
ZVA	Zimbabwe Veterinary Association

CHAPTER 1

DELIVERY OF ANIMAL HEALTH SERVICES IN AFRICA: AN OVERVIEW

"Nothing in the world is as strong as an idea whose time has come".

(Victor Hugo)

1.1 Introduction

Livestock development is a means of improving output from the agricultural sector of most developing countries, and poor animal health is recognised as the most important constraint to livestock production in Africa (Winrock, 1992). Post independence, progressive deterioration in the quality of veterinary care was observed practically throughout sub-Saharan Africa and this was linked to organisational weakness and limited financial resources of the various governments' animal health departments which were responsible for the delivery of animal health services (Anteneh, 1983, Anteneh, 1985, Anteneh, 1991, Cheneau, 1984, de Haan & Nissen, 1985). While consensus appears to have been achieved on the need to improve the system of delivery of animal health services, the exact mode of uniformly achieving this goal across the continent appears less clear and the goal itself has so far appeared elusive despite several efforts (de Haan and Bekure, 1991, Renard, 1996). While this dilemma persists, African countries continue to suffer economic losses from livestock diseases, and this "Diseased State" status is often used as a barrier to international livestock trade, as well as justification to apply price pressures resulting both directly and indirectly in substantial economic losses (Ellis, 1987). In particular, the livestock dependent populations especially in rural areas of Africa, continue to face poverty and nutritional deficiencies, as well as political and social marginalisation.

Privatisation was perceived as the answer to the teething problems facing the delivery of animal health services in Africa (CTA, 1985, de Haan & Nissen, 1985). The traditional public delivery of livestock health services was recommended for change, with the introduction of cost recovery. Private entrepreneurs are being encouraged to take over the provision of some of the services considered exclusively of private good, and for which the farmers are willing and expected to pay. However, it has emerged over the past two decades that geographical, socio-economic and political diversities existing in the different regions and countries of Africa have influenced the implementation of the recommended privatisation oriented policies, on the delivery of animal health services (de Haan and Bekure, 1991, Anon, 1993). Differences in the livestock production systems, population densities, prevailing diseases, and existing social and economic institutions have meant that, different organisational structures and strategies are required for the different sub-regions and countries (Cheneau, 1985, Doyle, 1992, Ndiritu and McLeod, 1995).

Particularly thorny, has been the problem of identifying the role of the different participants in the delivery system. The success of the delivery of privatised services in any country may now depend on a careful study of the prevailing conditions, and the identification of the appropriate level of participation of both the private and public sectors (Maddock, 1987). The identification for privatisation, of those privately inclined activities for which the clientele is willing and able to pay is therefore essential (Odeyemi, 1993, 1996b). Those activities that require continual public sector participation should equally be identified and a well co-ordinated delivery system involving both the private and public sectors in the right proportions should be put in place (Umali, Feder and de Haan, 1992).

With the adoption of the privatisation policy in Africa, also came the problem of determining whether private veterinary practices can be viable in some of the regions and countries, especially where smallholder livestock producers are concerned (Doyle, 1992, Umali *et al,* 1992). This problem is particularly important as it is increasingly recognised that the major goal of animal health services in developing countries must be the effective delivery of health care to smallholder livestock producers (Morris, 1995). In achieving this goal, techniques in economic analysis in animal health appear pertinent to understanding the decision making processes that need to be undertaken by the various participants within the delivery system. In particular, there is a need to carefully consider those economic policies that may impinge on the ability of smallholders and resource poor livestock producers to access health care services.

Most countries in Africa are thus at a cross-road with regards to the implementation of the privatisation policy reform. For a lot of these countries, the policy is yet to take off after nearly two decades of its introduction. In some countries where some policy-led privatisation has occurred, doubt now exists as to the success and indeed the wisdom of the whole exercise. However, the lack of impact and in some cases, the failure witnessed in the privatisation policy in the past, does not in any way discredit the policy as a veritable organ for economic development, but rather an indictment on the abilities of the proponents and executors to make the policy work (Renard, 1996). Identifying the appropriate socio-economic and cultural setting for implementing the various models of service delivery, has been the bane of most privatisation oriented policy initiatives. Since the aim of economic analysis is to indicate whether more or less resources should be allocated to influence a product or outcome, there is now quite clearly, a need to evaluate the economic consequences of the privatisation policy, both before and after its implementation, in the context of the African environment. (McInerney, Howe and Schepers, 1992).

1.2 Livestock production and health in Zimbabwe

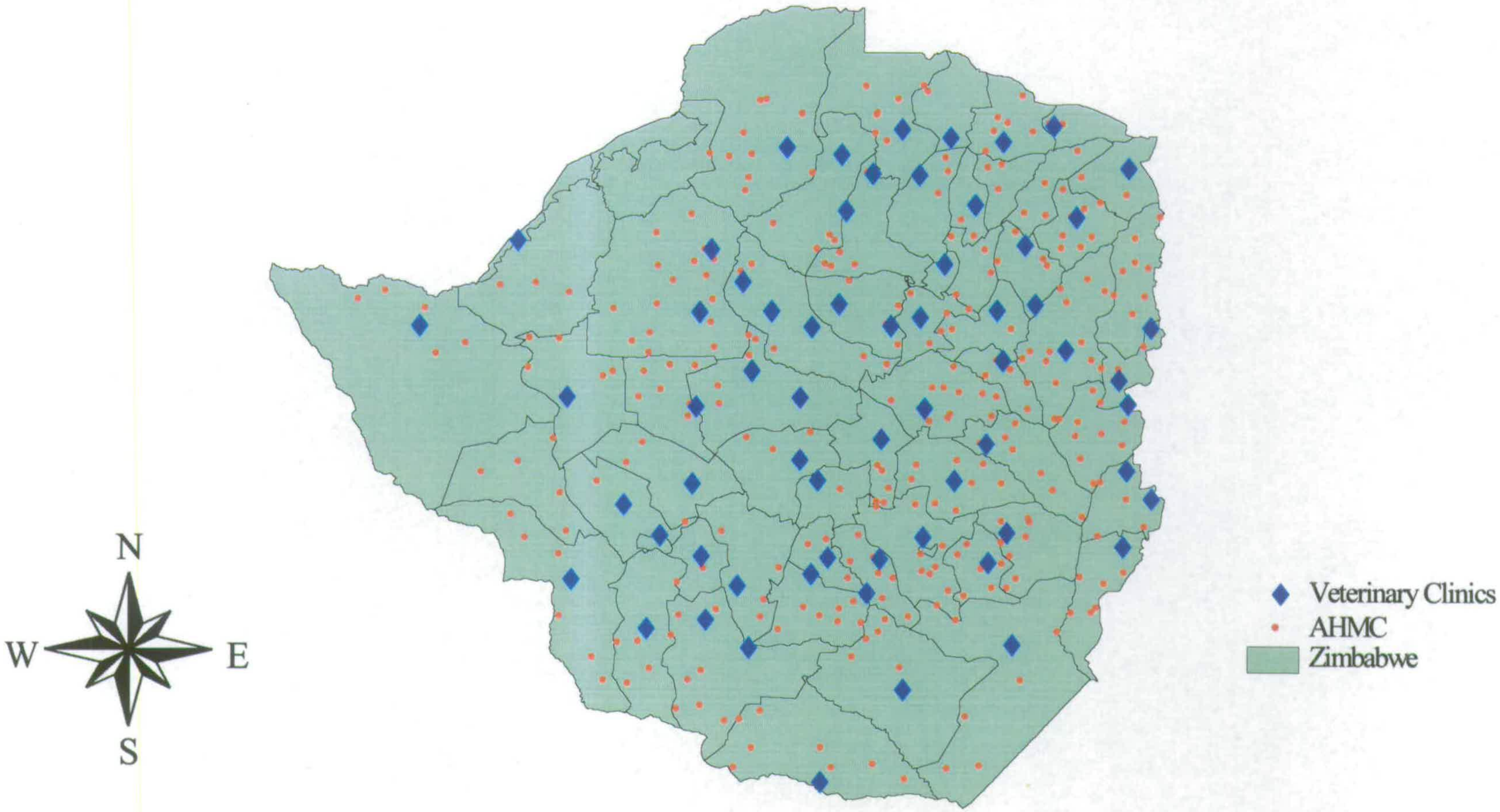
Zimbabwe is a tropical country, in Southern Africa, with a human population estimated at about 10.4 million, with about 50 percent of these living in rural areas (Census, 1992). It has an area of about 390,759 Square Kilometres. It is a landlocked country, divided into cooler high areas (Highveld) and much hotter low areas (Lowveld). Based on the rainfall, there are five natural regions in Zimbabwe, ranging from Region 1 with high rainfall, to semi-arid Region 5. Such ecological zones represent landforms with decreasing quality for farming purposes (GFA, 1987, Wanmali and Zamchiya, 1992). About 65 percent of the country is used for agriculture.

Agriculture is the largest employer of labour in the Zimbabwean economy, with over 70 percent of the labour force engaged in this sector. However, only about 17 percent of households rely on farming as the only source of income (Ulrich, 1994). The agricultural sector comprises of a commercial and a subsistence (non-commercial) sector. (Wanmali and Zamchiya, 1992). The latter is mainly found in communal and smallscale resettlement areas. The population of cattle in Zimbabwe is estimated at about 5 million. The value of livestock to the economy is over Z$ 2.5 billion as at 1992, beef exports average 12,100 tonnes annually (GOZ, 1992). Eighty percent of communal households keep livestock, and household cattle numbers range from about 2-10 per household. However, communal and small scale resettlement cattle are not produced for sale, they are kept mainly for draught purposes (Mutisi et al, 1994). Hence, communal cattle offtake range from 1.3 to 3.7 percent, and 5 percent per household when non-commercial offtake is included (Scoones, 1992).[1] Beef offtake in commercial farms on the other hand ranges from 16 to 26 percent. In addition to beef farms, there are about 450 registered large commercial dairy farms, producing about 250 million litres of milk annually (Mupunga, 1994). In addition, there are about 8,600 small scale commercial dairy farms with between 2-10 exotic dairy cattle, and producing between 2-5 litres of milk per day each (Nyathi, 1994).

The veterinary profession in Zimbabwe comprises of about 180 registered veterinarians, and several hundred para-veterinarians. These work both in the private and public sectors to provide veterinary services for the livestock and companion animal population of Zimbabwe (Zimbabwe Veterinary Register, 1996). There are about 22 spontaneous private practices in Zimbabwe (ZVA Survey, 1995). Eleven of these are situated in Harare, the capital city, and the rest distributed around a few other cities and provincial capitals. The private practices mainly serve pet and companion animals of the big cities, as well as the commercial livestock producers. The government's Department of Veterinary Services (DVS), comprises of field (clinical), research, meat hygiene and administrative branches (DVS Field Report, 1995). The department employs about 5,000 workers, about 80 of which are veterinarians.[2] Clinical services for non-commercial livestock is provided by a network of 63 government clinics located at district headquarters. These are supported by some 300 Animal Health Management Centres (AHMC) scattered mainly around the communal farming areas (See Figure 1.1). The district clinics are manned mainly by veterinarians while the AHMCs are manned by paraprofessionals. The services provided by the government are mainly free and include, statutory regulation, epidemic disease control, meat hygiene, dipping for ecto-parasites, diagnostic services and research.

[1] Sithole and Attwood (1991) reported income from livestock of communal households to be only about Z$ 212 per household per year.
[2] These figures apply to 1996, when this study was conducted.

Figure 1.1 Distribution of Veterinary Clinics and Animal Health Management Centres in Zimbabwe



However, of late, under the current Economic and Structural Adjustment Programme (ESAP), the DVS has witnessed a decline in its operational budget, just as has happened in other African countries where market economies operate. The DVS is now having to rationalise its services, a process that would include cost recovery and withdrawal of subsidy in services hitherto provided free. It is in the light of such privatisation oriented policy reforms that the need to be able to evaluate the economic and social impact of policy initiatives in the delivery of animal health services becomes pertinent.

1.3 Outline of research

Using Zimbabwe as a case study, this study aims at providing a framework for the economic evaluation of the delivery of animal health care, especially in rural areas of developing countries. Geospatial and econometric techniques will be employed to identify those areas and farming systems that will support private veterinary practices and by deduction, identify regions and farmers that are likely to require alternative delivery systems. The principal working hypotheses of this study is that:

> ***"The adoption of privatisation policy reforms, in the delivery of animal health services in Africa, will have adverse economic and social impact on the various stakeholders".***

In addressing the above general working hypotheses, a number of smaller research hypotheses can be derived. These smaller hypotheses constitute the subject of the various chapters into which this study is divided. In the first part of Chapter 2, the way in which the delivery system in developing countries evolved over time is traced, leading to the current privatisation policy in Africa. An attempt is then made to provide an in-depth picture of the social and economic context to the delivery of animal health services in Zimbabwe. In Chapter 3, a five step framework for the socio-economic evaluation of health delivery systems is developed, and the appropriate analytical tools described. The remainder of this thesis follows the framework as outlined in this chapter.

Chapter 4 takes the first step in the analysis of any system, by identifying and accurately characterising the constituent target stakeholders, who are in this case, the different producer groups. To achieve this aim, results of a survey questionnaire were analysed using appropriate statistical techniques. In Chapter 5, economic tools were utilised to determine the economic value of both the existing and latent demand for veterinary services in Zimbabwe. This step is clearly vital to any form of economic impact analysis. In Chapter 6, an attempt is made to identify the prevailing spatial dimensions within the delivery system. Geospatial models were adapted for use in this chapter. This resulted in the accurate dis-aggregation of the population, and permitted the analysis of the inherent locational efficiencies and inequities within the delivery system. The output of this chapter also provides essential data for further analysis in the subsequent chapters. Privatisation of services delivery ultimately produces profit maximising service providers. Using Linear Programming techniques, Chapter 7 permits the evaluation of the consequences of such profit maximising decision process on various aspects of the delivery system. In particular, the twin issues of economic viability and equity were investigated under the scenario of privatisation.

Since privatisation implicitly means cost-recovery and withdrawal of subsidy, Chapter 8 utilises the Linear Programming model developed in Chapter 7 to investigate the impact of various scenarios of subsidy withdrawal on the various stakeholders in the delivery system. Chapter 9 summarises the various hypotheses tested and the conclusions arrived at, and makes recommendations on possible policy interventions for the animal health delivery system in Zimbabwe, with possible extrapolation to other country situations.

CHAPTER 2

EVOLUTION OF THE INSTITUTIONS OF DELIVERY OF ANIMAL HEALTH SERVICES AFRICA

"to get hold of the more intelligent working blacksmith, and give him such a training in anatomical and clinical knowledge, as would fit him to treat the ailments of animals in a manner less barbarous than then in vogue"

(Dunlop and Williams, 1996) [1]

2.1 Introduction

Historical evidence shows that the treatment of animals has been taking place in Africa, almost four thousand years before the first veterinarian stepped into Africa at the turn of the century. Since the advent of orthodox veterinary medicine in Africa under the colonial administrations, and the subsequent independent governments, the delivery of animal health services has been predominantly carried out by the public sector, with little consideration for cost recovery and minimal private sector participation de Haan and Nissen, 1991). It emerged that the policies governing the development of the institutions of delivery of animal health services in both the colonial and the subsequent independent countries of the tropics, were based more on political considerations rather than any strategic planning. The emergent institutions were therefore fragile and susceptible to the vagaries of politico-economic instabilities and disease epidemics.

Deterioration in the quality of the delivery of animal health services later occurred and was blamed on economic difficulties encountered by the governments and the

[1] Objective for setting up the Royal (Dick) School of Veterinary Medicine, Edinburgh, by the Highland and Agricultural Scociety of Edinburgh, in 1823.

in-efficiencies perceived to be inherent in such public sector delivery system, and this has led to the call for a more efficient system with private sector participation (Anteneh, 1983, de Haan and Nissen, 1985). After a decade of advocating for a move away from a wholly public sector management, it is becoming more obvious that, success will depend very much on the understanding of the dynamics of the change being envisaged (Anon, 1993).

2.2 A historical perspective of animal health services

The term veterinarian, is suspected to have been derived from the Roman word "*veterinarus*" referring to a care-taker of pigs, sheep and cattle (Dunlop and Williams, 1996). There are two possible roots to the word "*veterinarus*". "*Souvetaurinarii*", a composite word for sacrifices involving pigs (*sus*), sheep (*ovis*) and bull (*taurus*), and the word "*veterina*", which refers to a pack of animals. The history of veterinary medicine however, extends well beyond the borders of Italy, the country that gave the profession its name. Orthodox veterinary medicine as we know it today, can be traced back to the years immediately leading to the establishment of the first veterinary school in Lyons, France, by Charles Bougelat in January 1, 1761. Shortly after his first school, Bougelat had established a second veterinary school at Maisons-Alfort in Paris in the year 1765. Other veterinary schools then followed in other parts of Europe, such as, Vienna 1766, Turin Italy in 1769, and London 1791 (Dunlop and Williams, 1996). The establishment of orthodox veterinary medicine can be considered completed with the subsequent opening of several veterinary schools in Europe.

The political, economic and scientific developments of the more developed countries appeared to have influenced to a great degree, developments in the animal health delivery systems of Africa and other developing countries of the tropics. Indeed, a comparative study of animal health services of different tropical countries shows that, they appear to have evolved through similar phases of development at about the same period of their history (Smith, 1973a). A study of the evolution of the veterinary profession in developing countries shows that their institutions of delivery of animal health services appeared to have gone through five recognisable phases of development.[2] These phases include the followings;

1- Pre-institutional era (Before the 1890s)

2- The era of colonial veterinary institutions (1890s - 1960)

3- Post-independence era (1960 - 1980)

4- Era of privatisation (1980 onwards)

2.2.1 The pre-institutional era (Before 1890s)

This era extends right from the very first recorded encounter between man and animals to the advent of orthodox veterinary medicine in Africa. The earliest recorded relationship between man and animals dates back to the Palaeolithic (Stone Age) era, about 100,000 BC. Then man was a hunter, and animals the hunted. The relationship changed slightly in the Neolithic period, about 10,000 BC, during which time domestication of animals by man began (Konczacki, 1978, Dunlop and Williams, 1996). While the Mesopotamians were the first to be credited with describing a "cattle healer", about 5,000 BC, the first detailed description of animal diseases was found in Africa, recorded in the Papyrus of Kahun in Egypt, about 2,000 BC. The Papyrus specifically mentioned diseases of the eyes, some form of gastro-enteritis and septicaemia. Although the Egyptian papyrus showed that the treatment of diseases of dogs and other animals took place in Africa as early as 2000 BC, this period was still characterised by the absence of orthodox veterinary medicine as well as established institutions of delivery of animal health services as it is known today. For, although most African countries had colonial administrations especially towards the latter part of this period, there were no veterinarians or veterinary departments in the colonies.

For most part of Africa, domestic livestock population were said to be "*low and limited by tsetse into islands of fly-free country*" (Smith, 1973b). Livestock marketing appeared to be poorly developed and off-take was more influenced by

[2] The structural dynamics of the changes to the institutions of service delivery seem to follow the classical epidemiologic revolutions as described by Schwabe (1982, 1993).

social rather than economic considerations. Most diseases were well known to the herdsmen, although orthodox medicine was not available to treat them (Bizimana, 1994). Epidemics of livestock diseases such as Rinderpest, Contagious Bovine Pleuropnuemonia (CBPP) and East Coast Fever (ECF) often swept unabated through several countries resulting in very high livestock mortality. The nomadic Fulani herdsmen of Nigeria for instance prescribe "flight" as the only effective protection against the scourge of Foot and Mouth Disease (FMD), a view they still hold even today. Apathysation, a process of conferring immunity to CBPP by the implantation of affected lung tissue above the nostril was described amongst herdsmen in the Gambia long before the arrival of orthodox medicine (Walshe, 1973). Migration, quarantine, branding and the administration of herbal treatments and ointments, as well as other ethno-veterinary practices are known to be commonly used in the treatment of livestock diseases in Africa during this era. Amongst the traditional healers, there appeared to be distinction between the general practitioners, who are often herdsmen, and specialists, who are recognised for treating special conditions such as fractures and dystocias (Bizimana, 1994). While some of the practices are effective, most are clearly not, hence the ravages of diseases that characterise that era.

2.2.2 The era of colonial veterinary institutions (1890 - 1960)

This era extends from the advent of the first colonial veterinarian to the attainment of independence in most countries. India was one of the first countries in the tropics for which there is a record of disease control by a veterinarian, a Mr W Moorcroft in 1808. In colonial Africa, the first veterinarians were reported to have arrived at the turn of the twentieth century following the Rinderpest pandemics of the 1890s (Table 2.1). Several of the veterinarians were military officers whose role was the reporting and control of Rinderpest, and especially the health of the military transport horses and bullocks of the colonial administrations. The development of veterinary services in the West Indies, unlike in Africa and Asia, occurred in response to developments in ranching, livestock breeding, and livestock trade especially in race horses. The veterinarians were also more inclined to private practice rather than government service, which was the case in Africa (Arnold and Guilbride, 1973, Metivier and Gonzalez, 1973). The civil veterinarians often train some African assistants and scouts with whom they subsequently formed the colonial veterinary departments. The veterinary departments that emerged were often part of the colonial administration's agricultural department, with the staff combining their veterinary roles and that of agricultural officer.

Table 2.1.

The Arrival of the first veterinarians in the Tropics.[3]

1808 - India - W Moorcroft
1890 - Zimbabwe - Lt. E O Farrel
1894 - Trinidad & Tobago - J B White
1895 - Guyana - J H Bell
1896 - Lesotho - W Robertson
1897 - Kenya - Capt. J A Haslam
1900 - Jamaica - R Rain
1902 - Sudan - Capt. V R Smith
1903 - Swaziland - W E Elder
1904 - Botswana - G W Lee
1909 - Ghana - W P B Beal
1909 - Tanzania - Dr Lichtenheld
1909 - Uganda - E Hutchins
1910 - Malawi - G Gordon
1914 - Zambia - A Lane
1914 - Nigeria - F R Brandt
1924 - Somalia - T A B Cocksedge
1929 - Gambia - E V Earnshaw
1942 - Sierra Leone - Dr G N A Hall

(Source. Smith, 1973a)

Their main function of the prevention and control of major livestock diseases was greatly enhanced by improvements in diagnostic skills and knowledge of tropical diseases, and by the discovery at about this period, of several drugs and vaccines for the prevention and treatment of several livestock diseases, and these include vaccines

[3] Record of Francophone countries not available at the time of writing,, but assumed to be similar to trend in neighbouring Anglophone countries.

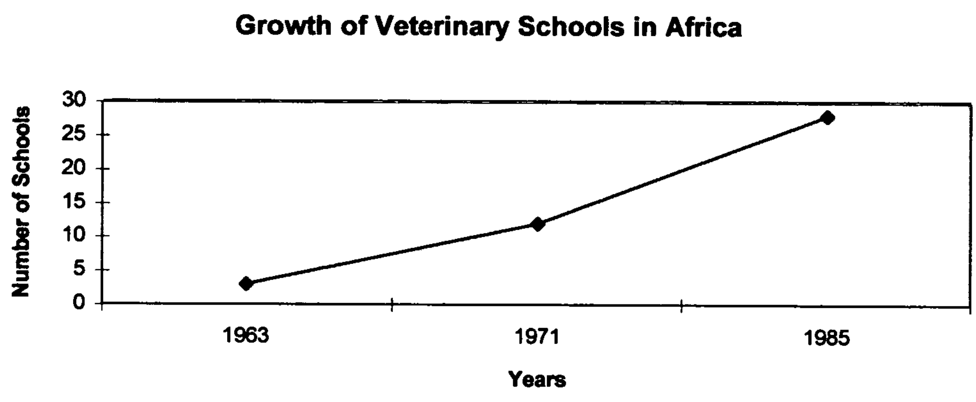
for Anthrax, African (East) Coast Fever, Rinderpest and CBPP, as well as trypanocides (Naganol) for the treatment of Trypanosomiasis especially in camels. Other services were subsequently developed usually in response to the needs of the colonial home governments or administrations. Thus emphasis was laid on services such as stud breeding schemes for transport horses for the military, meat inspection, hides and skins inspection for the export trade, with other extension services acquiring different levels of importance in different countries. In addition to the informal training of veterinary assistants, the demand for trained manpower was addressed by the establishment of veterinary schools. A veterinary school was established in Bombay, India, in 1886, with one established forty years later at Makerere University in Uganda in 1927 (Carmicheal, 1973). Later, schools fashioned after the Makerere Veterinary school were established in Khartoum, Sudan in 1937 and later in Nigeria. A number of veterinary laboratories were established, including one at Kabete in Kenya (1910), Entebbe, Uganda in 1921, and the Vom laboratory in Nigeria (1922), for the diagnosis of livestock diseases as well as the production of vaccines (Henderson et al, 1973, Macaulay, 1973).

2.2.3 Post-independence era (1960s - 1980s)

Newly independent African countries inherited the veterinary institutions and policies of their colonial administrations, with veterinary services being provided by the government departments free of charge. The veterinary departments were responsible for policy formulation, disease surveillance and control, clinical services, public health functions, drug procurement and distribution. They also were responsible for extension services such as breeding and livestock improvement. During the period immediately post-independence, in fulfilment of promises made to the electorate, the public services, including the veterinary departments witnessed a lot of growth, especially of personnel, due more to political, rather than to any strategic planning reasons (de Haan and Nissen, 1985). The wealth acquired from a booming export trade especially in primary agricultural produce, mineral resources, and oil (in some countries), during this period, further encouraged this growth. Existing veterinary infrastructure was therefore expanded, in most cases well beyond required capacity, and these included the construction of more clinics, diagnostic laboratories, artificial insemination, livestock breeding centres and cattle dips.

The number of veterinary faculties in Africa rose from three at independence to twenty eight within two decades (Figure 2.1), representing about one veterinary school established per year (Pritchard, 1988, Smith and Hunter, 1990). Expectedly, this resulted in a corresponding rise in the population of veterinarians. For while the population of veterinarians in Africa was estimated at only about 2,500 in 1964, the population rose to over 42,000 two decades later. Most veterinarians work in government departments because they were automatically employed by the governments on completion of their training (AHYB, 1992). Similarly, several schools for the training of para-veterinarians were established. These measures collectively resulted in an explosion in the personnel population of most veterinary departments in Africa. This era also witnessed the nationalisation of the few privately owned livestock industries such as ranches, meat processing and packaging industries, as well as the placing of the livestock marketing boards fully under government management.

Figure 2.1



Source. World Directory of Veterinary Schools (1971), and Pritchard (1988).

Similarly, the procurement and distribution of veterinary drugs were taken over by the government in most countries. These actions in addition to other fiscal measures such as the imposition of import licences and foreign exchange restrictions discouraged private initiatives, and resulted in the shrinkage of what already existed, especially where foreign inputs were involved or required. These over-ambitious recruitment, staff training and development programmes resulted in most veterinary departments becoming over-staffed, especially as the livestock industries were not undergoing a corresponding growth. A direct consequence of this was the emergence and growth, over time, of unemployment of veterinary professionals, a phenomenon hitherto unknown. This occurred as the veterinary graduates produced were unable to gain automatic government employment due to budgetary constraints, and such graduates were usually unable or unwilling to set up private practice. Towards the latter part of this period also, a global economic recession, coupled with administrative in-efficiencies, resulted in the inability of the governments to adequately fund their animal health services. Staff salaries took a disproportionately larger portion of the departmental budget while operational funds progressively decreased (Anteneh, 1983, 1985). The consequence of this was that there were drug shortages, lack of transport and obsolete and defective working equipment resulting in field staff becoming ill-motivated and in-efficient. An average of 30% veterinary coverage was reported for most part of Africa (Huhn, 1990) and hitherto controlled diseases began to re-emerge such as characterised by the Rinderpest outbreak of the late 1970s and early 1980s (de Haan and Nissen, 1985). It was this scenario that led to a period of advocacy for restructuring of government veterinary departments and the privatisation of veterinary services.

2.2.4 Era of privatisation (1980 onwards).

Although this period is referred to as the era of advocacy for privatisation, thereby implying that privatisation is a new concept, historical record abound to show that some private practices have been in existence in some countries even as early as the advent of orthodox veterinary medicine. The first veterinarian to practice in Jamaica, R Rain 1900, as well as some of the other countries of the West Indies were actually private practitioners (Arnold and Guilbride, 1973). This being linked to the development of ranching and livestock export trade that existed at that period.

Similarly, Lt. E O Farrel (1890), the first veterinarian in Zimbabwe, was recorded as retiring a few years later into private practice at Bulawayo (Lawrence, 1973). In Morocco, the law regulating private practice was enacted as far back as May 12th, 1914 (Fassi-Fehri and Bakkoury, 1995). Similarly, several retired colonial veterinary officers settled in Kenya (1930s-1940s), and went into private practice, especially after the value of livestock increased following improvement in cattle breeding. On the other hand, cost recovery was said to have been practised by a government veterinary officer in Somalia, Cocksedge (1925-1936) in the treatment of Trypanosomiasis in camels with the newly discovered though expensive "Naganol", while there were charges on the cattle quarantine farm in Zimbabwe in 1891. Over the years also, private practice flourished in most urban cities in Africa where there was affluence, and in those rural areas with smallscale commercial dairy, poultry and pig production (AGREF, 1986, Odeyemi, 1994b, Wamukoya et al, 1995). Despite these isolated cases of spontaneous privatisation, animal health services has been delivered, predominantly by government veterinary departments in most African countries. Animal health and extension services appeared to have been spared the structural adjustment that other industries in the developing countries were undergoing in the latter part of the 1970s.

However, as the budgetary constraints persisted, so did the deterioration in the delivery of veterinary services in most countries, resulting in a call for restructuring of the animal health delivery systems to stem the economic loses being encountered. Consequently, international efforts at promoting privatisation were embarked upon as alternative to government controlled livestock health delivery systems (CTA, 1985)[4]. These efforts were geared towards achieving the followings (PARC, 1993):

1- A change in attitude towards accepting the privatisation of services and cost recovery.

[4] The Pan-African Rinderpest Campaign (PARC) programme was set up in 1986 with the aim of coordinating the improvement of animal health care delivery in Africa. The European Union allocated ECU 92.4 for this purpose (Renard, 1996).

2- The encouragement of private veterinary practices to take over certain curative and preventive functions.

3- Public sector reforms including the scaling down (down-sizing) of staff strength so as to improve management for a proportional increase in operating funds.

4- Liberalisation of drug and input importation and distribution.

2.3 Experiences with privatisation in Africa

Over a decade of advocating and experimenting with restructuring and privatisation has however resulted in very little real increase in the proportion of private to government veterinarians in most African countries. In some countries, there was actually an increase in the ratio of government to private veterinarians during this period, despite the governments' acceptance of the privatisation policy (Umali, Feder and de Haan, 1992, Perry, 1997). More alarming however is the fact that most African governments seem to have abandoned the delivery of animal health services, while the private sector is not yet ready to take over (Shayo and Kavishe, 1996). A similar scenario has been reported for Latin American Countries (Anon, 1998). Overall, Renard (1996) concludes that PARC has not led to any significant improvement in the management of natural resources in the region.

An analysis of the current state of the policy in a number of countries reveals that a general lack of understanding of the concept of privatisation and the underlying principles, is responsible for the abysmal performance of the privatisation policy in most countries. This is often characterised by the absence of a favourable institutional framework for the privatisation policy in most country (Odeyemi, 1994a, Odeyemi, 1994b, Shayo and Kavishe, 1996, Godana, 1997, Haile-Mariam, 1997, Turkson, 1998). The introduction of cost recovery and the support for the setting up of private veterinary clinics which were considered desirable have not taken off as planned, despite several initiatives (Renard, 1996). Meanwhile, such schemes that have been instituted over the past decade, aimed at improving the poor state of the animal health delivery services, appear to have mostly stalled (Shayo and Kavishe, 1996). A careful study of the situation in Africa, points to the followings as impediments to the successful implementation of policies aimed at improving animal health services:

1- Government preference for the strengthening of veterinary departments

There is a preference by the government livestock departments, for the strengthening of existing government veterinary institutions, rather than the support for newer initiatives which the privatisation policy, and the other cost recovery projects represent (PARC, 1993). This is despite the declared acceptance by the governments of the principle of privatisation, deregulation and cost recovery. This attitude is characterised by a covert lack of enthusiasm for, and in some cases, outright opposition to any project that does not involve direct funding for, or the supply of inputs to the government departments or ministries (Renard, 1996). Several problems presently being encountered are as a result of this "delaying tactic", and such adverse attitudes to privatisation and other similar initiatives is reflected in problems on the ground. One encounters for instance, government delay and unwillingness to pay up their share of agreed joint-funding for projects, as well as the absence of legislation for the establishment of private practices, veterinary drug acts, legislation pertaining to the importation of drugs and inputs, as well as arrangements governing the withdrawal of government veterinary departments from the delivery of services better performed by the private sector. Agencies responsible for co-ordinating these projects use the above reasons as an excuse to withhold funds for private practice projects. This is largely responsible for the current lack of progress for such programmes in many developing countries.

2- Deficiencies in appropriate technical and business skills

The small number of private practice models in Africa, has denied the veterinary profession the technical and business skills needed to succeed in this diverse and often difficult African practice environment. Such skills are often not taught in veterinary schools but are acquired through working in existing practices. The consequence of such deficiencies is a lack of self confidence on the part of the veterinarian and a reluctance to go into private practice, whether freshly graduated or currently in government service (Odeyemi, 1993, Shayo and Kavishe, 1996, Haile-Mariam, 1997). Several reasons advanced by such reluctant veterinarians include non-viability of private veterinary practice in Africa, inability and unwillingness of farmers to pay for services or competition from non-professionals. However, when the situation is analysed, these reasons have often been shown not to be true. The need for retraining veterinarians in appropriate technical and business skills, and the provision of essential business support such as accurate feasibility and financial viability studies, business plans, as well as financial and management advice can not be over emphasised. Similarly, government officials need to acquire the right skills to manage the required changes, while the undergraduate veterinary curriculum must be reorganised to reflect the added veterinary practice management skills essential for success in a private practice career (Wise and Kushman, 1985). The recognition, training and integration of the para- veterinary cadre of workers who will provide services to the rural and less favoured communities, is equally important. Such a step is now recognised as essential to the improvement of the overall development of animal health services, while ensuring contrôl over their activities, as well as the full utilisation of available manpower and the wealth of experience some of these cadre of workers must have acquired over the years (Odeyemi, 1994b, McCorkle and Mathias, 1996). It is considered that, integrated professional and para-professional animal health delivery services is the right way forward.

3- Erratic drug and input supply

The erratic supply of drugs and inputs essential for the sustained delivery of effective animal health services is a major problem in most parts of Africa (Godana, 1997). This becomes particularly important in private practice, where the success or failure of any particular practice and indeed the whole privatisation programme can be dependent to a large extent on this factor. The provision of appropriate means of transport, the acquisition of essential equipment, and a reliable and sustained supply line of the essential drugs at reasonable costs, must be components of the total package of privatisation, and any programme to improve animal health delivery in Africa (Odeyemi, 1994a).

4- In-adequate financial support

The lack of start-up funds has been cited by veterinarians in most countries as the main constraint to going into private practice (Odeyemi, 1994b, Godana, 1997, Turkson, 1998, Wamukoya et al, 1995). However, even in those countries where start-up funds have been made available by international agencies such as the European Union and the World Bank, unfavourable lending rates, and conditionalities such as collateral have often prevented uptake by prospective private practitioners (PARC Tanzania Report, 1996). Furthermore, qualified financial and management advisory agencies are often lacking in most countries, resulting in defective financial planning and resource management.

5- Other enabling institutions

The absence of virile professional veterinary associations in most African countries means that, enabling legislation and technical support are often not in place, or take too long to be established (Godana, 1997). This often delays or actually stalls privatisation and other policy initiatives. In those areas where legislation's do exist, they are often not enforced. In particular, legislation relating to right to private practice, unfair competition, ethical conduct, and drug handling, are quite often not in place or widely flouted, where professional associations are not in existence or are weak. Since it is unlikely that the privatisation policies will be reversed in most developing countries under the prevailing economic situation, it is essential that the above issues are given adequate attention as most countries move into what can only be referred to as a prolonged "Era of Privatisation".

2.4 Understanding privatisation

The term privatisation is used in industry as representing the "transfer" of productive assets from the public to the private sector, and this could involve either a direct sale, lease or management contracting arrangements, such as the sale of a government ranch, or management contract to manage a dairy company (Maddock, 1987). In the delivery of animal health services however, the privatisation policy essentially represents "a change in the supplier of animal health services from the public to the private sector". While this definition specifies who supplies the services, it does not say who pays for the services. It is therefore important to emphasise here that the source of payment for the services rendered could either be the public or private sector. The obvious reasons for African governments to advocate for the privatisation of animal health services essentially revolve around the stemming of the deterioration noticed in their delivery system. However, privatisation being a global policy, has been associated with various other objectives in other industries, some of which may or may not apply to the health care delivery system. Experiences in such other industries have been widely documented (Meadley, 1990, Thirtle and Echeverria, 1994, Engberg-Pedersen, et al, 1996, Adam et al, 1994, Semboja and Therkildsen, 1995). From those experiences, the objectives often put forward by the advocates of privatisation can be summarised as follows (Odeyemi, 1997a):

1- Public finance rationalisation.

It is perceived that in the short term, privatisation will enhance the financial standing of the governments especially from income accruing from asset sales, or the reduction of the financial burden of government for providing a service, where withdrawal from service delivery is involved.

2- Economic efficiency

This assumes that the delivery of services is more efficient under private management than where the government is involved (Nunnenkamp, 1986). While this need not be true, it is obvious that private managers have a greater incentive to be efficient either through having a share in the business, or having higher remuneration than their public sector counterparts in the same post. Secondly, the beaurocracy of the public sectors often interfere with efficient supervision of workers, a problem not commonly seen in the private sector. Thirdly, since most public service delivery systems such as animal health services are monopoly systems, there is often no direct and sufficient competition, hence, less incentive to be efficient.

3- Private sector development.

It is thought that within every public sector delivered service, there is a potential role for the private sector, assets often not exploited due the monopoly and often times, subsidised public service. The contributions of these "nascent" private sector participants are often activated by privatisation (Meadley, 1990).

4- Domestic resource mobilisation.

Under public sector management, most individuals within the population keep their savings as fixed and unproductive assets. Privatisation is thought to encourage individuals to cash and invest their resources. On a national level, this could result in the development of the capital market. Similarly, human resources are equally mobilised, as unemployed professionals are encouraged to go into practice, and are not prevented from working just because they can not get government employment.

5- Equitable social distribution of services.

While equitable distribution is one of the claims for public sector delivery of services, political interference and inefficiency often prevent the attainment of this objective. With privatisation however, an efficient demand and supply objective ensure that those that actually need the service get it, at the appropriate value of the service Nunnenkamp, 1986).

6- Enhancement of government standing with external creditors.

Since privatisation is one of the conditionalities for continued external support under the structural adjustment programme, compliance enhances government standing and encourages further support with potential for greater development (Griffith-Jones, 1988).

2.5 Discussion and conclusion

The delivery of animal health services in most African countries is presently at a crossroad. The persistence of budgetary constraint faced by most African governments has continued to diminish their ability to fund an adequate animal health delivery service, with most government veterinary departments and clinics poorly resourced, and over-staffed with demotivated personnel resulting in animal health problems being left unattended. A considered study of the current state of the privatisation policy points to institutional constraints as the major limiting factor, and this has arisen from a general lack of understanding on the part of the various participants, of the basic principles governing the privatisation policy (Perry, 1997). The result of this, is the adoption of the wrong attitudes that have limited the rate and level of progress that might have otherwise been achieved, since the introduction of the policy in many countries (Thirtle and Echeveria, 1994). Private practice has been shown to be quite viable under certain situations in several countries, and the privatisation policy is perceived to be most appropriate particularly and irreversible at this time (Renard, 1996, Omore et al, 1997). This is due mainly to the persistence of government budgetary constraints, which make it unlikely for most government to continue to provide large scale subsidy for veterinary services. Pressure from livestock producers who are both willing and able to pay for services, as well as donor conditionalities from the likes of the World Bank and the European Community, makes the privatisation process irreversible under the current economic situation in developing countries of Africa, Asia, Latin America and even Eastern European countries. While direct clinical and preventive services are more appropriate for total privatisation, and delivered by private veterinarians, the governments should retain regulatory services, training and research, surveillance, quality control and enforcement services. Similarly, the government may be required to subsidise services in rural areas in some cases where veterinary services are needed but private practice may be discovered to be non-viable (Odeyemi, 1997a, Omore et al, 1997). It is important to note however, that, success with the privatisation policy can only occur when there is a clear understanding of the essential principles on which the policy is based. Five general principles are now recognised to govern the successful establishment of the privatisation policy in any country:

1- Privatisation is not an "all or none" process.

This implies that the policy involves "task sharing" between the public and private sectors, and "co-responsibility" between the government and farmers. In the framework of privatisation therefore, it is expected that certain functions such as policy formulation, regulation and enforcement will continue to be performed by government departments, while other functions that are privately inclined such as clinical services will be taken over by the private sector. Similarly, certain services that are considered to be more of public good such as, Tuberculosis and Brucellosis testing and in some cases, eradication campaigns may have to be funded by the government, while other services deemed exclusively of private good, such as clinical treatments should be fully paid for by the farmers.

2- Privatisation is a "dynamic" process;

Privatisation is seen to differ from one place to another (spatial variability), and changing with time (temporal variability). The appropriate private practice models therefore, not only vary from one agro-ecological zone of a country to another, but must also be recognised to change and require review from time to time.

3- Privatisation policy is a "desirable" policy for most countries at present.

This is as a result of persistent government budgetary constraints, as well as donor conditionalities such as is presently attached to the World Bank funded livestock development programmes, as well as the European Community funded projects. There is also additional pressure from livestock producers who are willing and able in the majority of the cases to pay for quality services, as several surveys have shown.

4- Privatisation level is "predictable";

By studying the prevailing socio-economic and livestock /disease related factors in any country or area, it should be possible to "predict" the level and model of privatisation appropriate to such an area. Similarly, areas where private veterinary practices are perceived not to be viable such as is the case in some rural and pastoral areas, the level of subsidy required to sustain a practice in the area, or the appropriate model and or combination of interventions can be readily determined.

5- Privatisation is "evolutionary" and not "revolutionary"

The spatial and temporal variations observed with privatisation, coupled with differences in the levels and rates of development of enabling institutions both within and between countries suggests that privatisation process in Africa must be evolutionary rather than revolutionary to be successful.

It can be concluded therefore that, the veritable next step must be the development of a methodology or framework that will facility accurate evaluation of the dynamics of the delivery system. This way, it should be possible to determine the appropriate model of practice that would be best fitted to provide a service for the different segments of the population.

CHAPTER 3

A CONCEPTUAL FRAMEWORK FOR EVALUATING THE DELIVERY OF ANIMAL HEALTH SERVICES.

3.1 Introduction

Current social and health care reforms in developing countries, especially within sub-Saharan Africa, have brought to the fore the problem of monitoring the efficiency of service delivery and the equity of access by all the population (Lavy et al, 1996, Bolduc et al, 1996). Although the need for developing a framework for the systematic evaluation of the delivery of animal health care services is apparent to a lot of scholars, a universally acceptable and workable framework does not yet exist (Doyle, 1992, Umali *et al.,* 1992, Odeyemi, 1993, Mlangwa and Kisauzi, 1994). However, it is expected that a framework for evaluating the delivery system must be holistic, and involve the integration of the different methodologies for evaluating the different components of the delivery system (Doyle, 1992). It is recognised that the full potential of the various existing methodologies can only be realised through integration (Revie et al, 1996).

A major difficulty encountered by planners, especially in Africa, is the inherent diversities within their delivery systems. These differences make the development of a universally applicable methodology or even a framework difficult. In particular, epidemiological and socio-economic differences have been recognized as influencing the type and efficiency of health care delivery systems (Schillhorn van Veen, 1984, Odeyemi 1996b, Odeyemi, 1997a, Majok, 1996). The recognition of a spatial dimension to service delivery in particular, is indicative of the need for area specific methodologies and interventions which will identify and address the specific health care needs of the different segments of the population (Odeyemi, 1997b, Odeyemi, 1998a, Odeyemi, 1998b). This way, in addition to achieving efficiency objectives, equity of access can be ensured. The working hypothesis of this chapter therefore involves *the possibility of accurately evaluating the efficiency of delivery of animal health services under the divers socio-economic systems, as well as geographical locations in Africa and other developing economies.*

In general, it is recognized that health care delivery systems comprise of three interacting components or institutions: the service providers, the recipients of services and the institutions or environment within which the services are provided (Cheneau, 1985, Odeyemi, 1993, Odeyemi, 1996b, Ndiritu and McLeod, 1995, Holden et al, 1997). Within these broad categories, Doyle (1992), without proffering a working framework, identified six elements comprising a decision matrix developed for the evaluation of any livestock delivery system. These elements include:

- Planners and beneficiaries
- Agro-ecological zones
- Agricultural production systems
- Health care determinants
- Institutional determinants
- Socio-economic issues

Kleeman (1996) suggests a framework for the evaluation of the livestock services delivery and this can be summarized as follows:

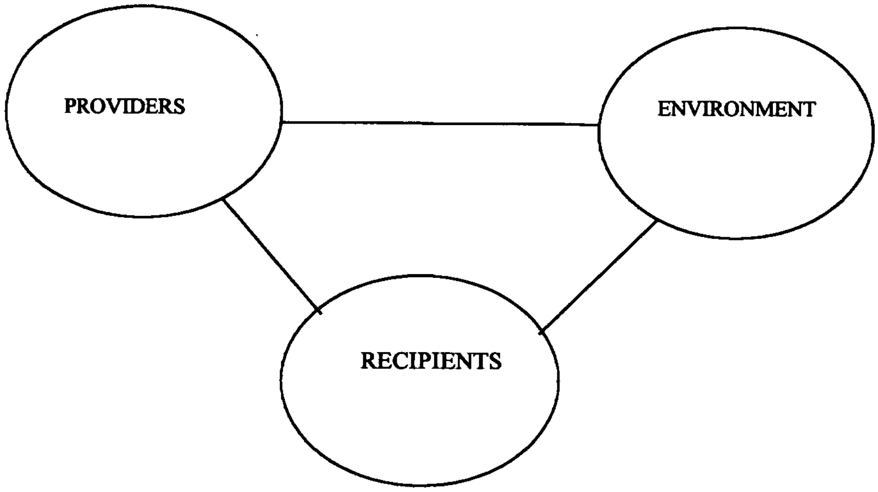
- Conceptualization of the problems
- Evaluation of service supply dynamics
- Evaluation of the service demand dynamics
- Assessment of the service efficiency
- Approaches for improving service efficiency.

While the Kleeman framework constitutes a useful first step in understanding the delivery system, empirical evidence is however unlikely to emerge due to its open-ended nature. Other workers have developed frameworks which, rather than being holistic, have looked at different constituent parts of the delivery system. These include the structural dynamics of the providers (Cheneau, 1985, Odeyemi, 1993), the socio-economic characteristics of the recipients (Majok, 1996, Hefferman and Sidahmed, 1998), the characteristics of the services (Morris, 1995, Mlangwa and Kisauzi, 1994, Umali et al, 1992, de Haan and Bekure, 1991, Leonard, 1985), as well as the socio-economic and institutional environment within which these services are provided (Schillhorn van Veen and de Haan, 1995, Anteneh, 1991, Odeyemi, 1993). Doyle (1992) recognized the inherent diversity within each of these elements above, as well as the difficulty likely to be encountered in their analysis, as a result of the inter-relationship between them. Further more, he identified the existence of spatial variations that exist, both between and within, the different regions and countries. This led Doyle (1992) to suggest the combination of predictive models and other decision support tools as the only means of analyzing the delivery system. More recently, application of such an approach has been variously described as Integrated Decision Support System (Dijkhuizen et al, 1997) and Portfolio Theory (Galligan and Marsh, 1997).

3.2 Structural dynamics of the delivery system

Two important characteristics of the animal health care delivery system influence the efficiency of service delivery. Firstly, it is recognized that the different components do interact, and these interactions do exhibit spatial variations. Thus, any framework for evaluating the delivery system would entail *the analysis of the various constituent components and their interaction over space* (Figure 3.1). The introduction of a spatial dimension to the framework would ensure that health care needs, and resultant interventions, are area-specific and therefore targeted and more appropriate. Secondly, the efficiency of delivery of animal health services would depend on the levels and appropriateness of the services vis-à-vis the specific health care needs of the population. Since no population is homogenous, it then implies that health care needs are likely to be varied between the various socio-economic groupings or prevailing stratification within the population.

Figure 3.1.
Interacting Components of the Health Care Delivery Systems



It then follows that the efficiency of delivery of health care services would also depend on how services are targeted to meet the needs of the different strata of the population. *A framework for evaluating the efficiency of health care delivery systems would therefore involve the identification and qualification of the various constituent population, their spatial distribution, specific health care needs and the socio-economic environment within which they exist.* The accuracy with which the above elements of the population are defined will inform the level of efficiency and appropriateness of health care interventions within the delivery system (Ndiritu and McLeod, 1995, Lavy et al, 1996). The above therefore makes a case for the concept of Precision Service Delivery (PSD) framework in health care delivery systems. The complexity of developing such a framework is greatly reduced when one considers that, whatever the spatial variations exhibited within the whole system, they are simply a combination of individual situations at one particular place and time, and each of these can be individually analyzed.

3.3 The Precision Service Delivery (PSD) Framework

Recent advances in science, culminating in the development of better analytical tools, accurate positioning systems, and information processing and management technologies, have improved the prospects of greater efficiency in the planning evaluation and implementation of health care policies and interventions. The concept of Precision Service Delivery (PSD), which is not dissimilar to its equivalent in agriculture is based on the premise that population is not homogenous, and thus, health care needs for the various segments of the population would be variable (Odeyemi, 1998c). Furthermore, because population is often distributed unevenly over space, a spatial dimension need be considered to health care delivery.

PSD framework is therefore aimed at adjusting and "fine-tuning" the delivery of health care services so as to meet the specific health care needs of the different segments of the population where ever they may reside. The concept is inherently demand-led, thus different services would be adapted to different population groups residing in different locations, resulting in specific and targeted service delivery. The procedure has several advantages over orthodox planning techniques and these include:

1- Enhanced efficiency of allocation of resources thereby reducing waste.

2- Specific targeting of services which will bring about equity in resource allocation.

3- Because services are demand-led, uptake of interventions will be enhanced with the resultant economic and health benefits.

4- Decision making process will be greatly enhanced due to better prediction.

There are five steps to a PSD framework (Figure 3.2):

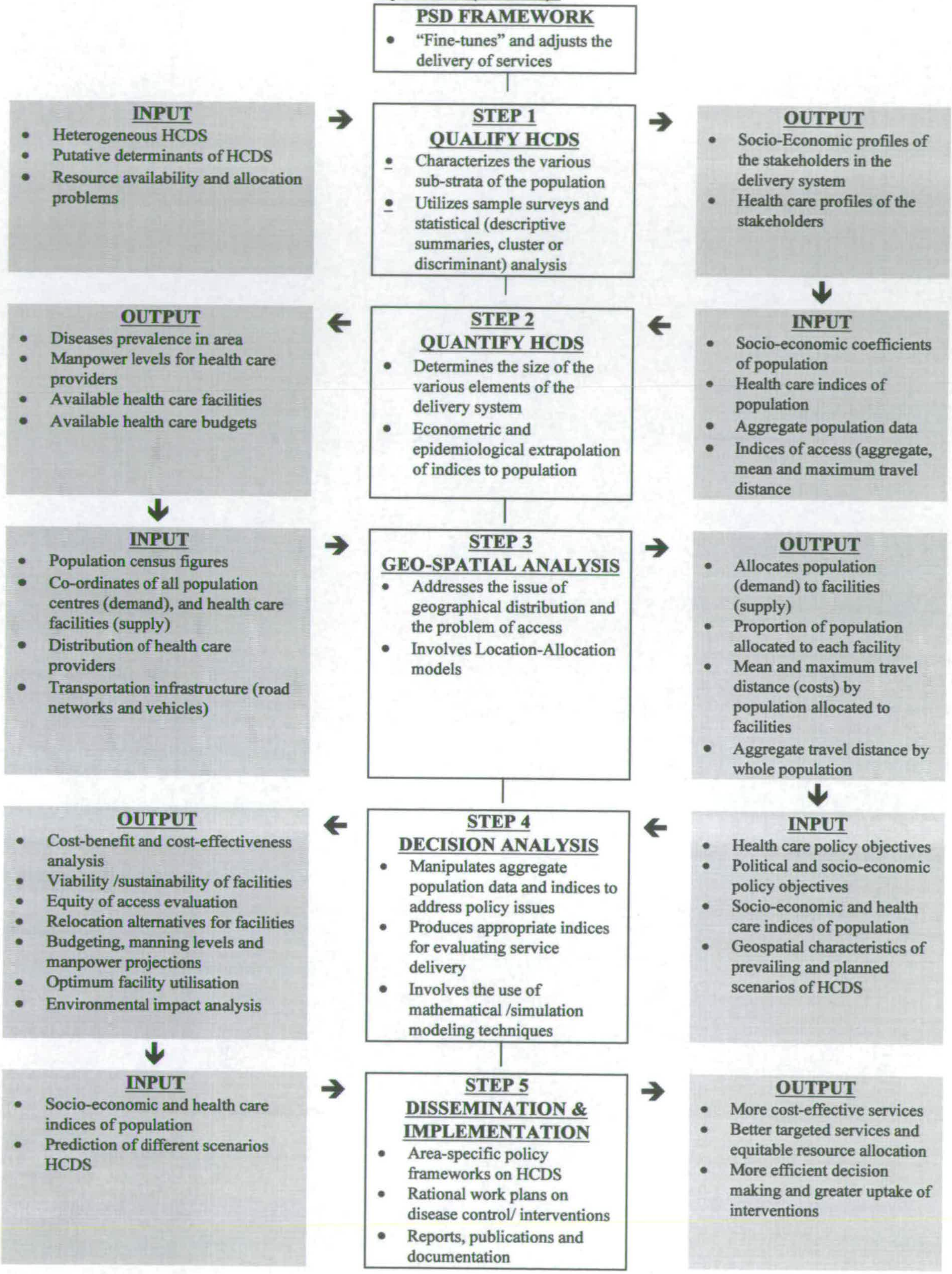
Step 1. Qualifying the various elements of the delivery system. This involves the identification of any existing strata or categories within the population, and the statistical validation of the categories as distinct units relevant to the health care issues being considered. Statistical techniques such as factor analysis would be useful in achieving the required categorization. This process permits the profiling of the population with regards to specific health care indices.

Step 2. Quantifying the health care demand elements. This involves determining the levels of specific health care needs for the different segments of the population as identified in Step 1. This will usually involve quantifying the level of disease or health care demand in the various segments of the population and or the economic value of same, through some epidemiological and or socio-economic survey techniques. These are then extrapolated to the whole population. A major limitation of this procedure however, is the likelihood of sampling inadequacies since such population characterization which is an important component of the analysis will be based on samples to be drawn from within the whole population.

Step 3. Spatial dis-aggregation of demand and supply. Through the use of Geographical Positioning System (GPS), Geographical Information Systems (GIS) and other geo-spatial modeling techniques such as Location-allocation models, the specific health care demands of the various population segments as well as infrastructure for service delivery can be geo-referenced.

Step 4. Rationalize service delivery options. When the various health care needs of the population and their distribution over space is known, vis-à-vis available supply resources, it is possible using decision support tools such as mathematical models to simulate and predict various service delivery policy options. This will permit a more rational decision making process depending on the policy objectives being pursued.

Figure 3.2.
<u>Precision Service Delivery (PSD) Framework for Evaluating Health Care Delivery Systems (HCDS).</u>



<u>N.B.:</u> HCDS= Health Care Delivery Systems

Step 5. Dissemination and implementation of policy decision. When various service delivery options have been identified and rationalized, it is often necessary to disseminate the information before or during implementation. Geographical Information System (GIS) tools are now available to assist with the management and display of such information.

3.4 Characterization of the delivery system

Qualifying the delivery system essentially involves the characterization of the various elements within the system such as the recipient population, the provider groups as well as the environment within which services are provided. This is done on the premise that:

1- there are differences in health care needs between the different sub-sections of the population,

2- these different health care needs require different provider institutions

3- prevailing socio-economic and political institutions influence health care demand as well as ability to provide the services.

In human health care delivery, population stratification is often related to the identification and classification of the population on the basis of their socio-economic and cultural attributes such as household income levels, education, nationality or race, as well as economic activities engaged in (Lavy et al, 1996). It is shown for instance that humans in the lower income brackets often have poor health or that community based primary health care providers are more appropriate for rural populations (Ettner, 1996). In the delivery of animal health care services however, characterization is based on detailed information with regards to the elements of the prevailing livestock production systems (Little, 1984, Doyle, 1992). Elements of the production system often analyzed include:

- Numbers and breeds of animals kept

- Objective of production (subsistence or commercial)
- Production activities, whether livestock or mixed farming
- Management practice (nomadic, sedentary, zero-grazed, e.t.c)
- Geographic character of production system (agro-ecological zoning, proximity to urban areas)

The provider classification on the other hand, is either related to the level of professionalism, in which case, they are either qualified veterinarians or various cadres of para-professionals, or the provider's sector of employment such as private practitioners or government employees (Cheneau, 1984, Cheneau 1985, Odeyemi, 1993). In general, categorisation whether of the population or of providers, is often based on putative determinants which often require validation. As discussed earlier, the validity of the classification of these groups can be tested using appropriate discriminating statistical techniques. Where classes are confirmed to be valid, the population within the various different categories are determined for the whole population, either through taking a census of the whole population or sampling and extrapolation.

3.5 Indices of health care delivery systems

The next essential step in the evaluation of the delivery of health care services involves quantifying the various elements of the delivery system. The outcome of this step would be to provide quantitative information on a particular attribute of a population under study, for instance the size of a disease problem in an area. This often involves econometric or epidemiological extrapolation of some identified health care indices to the whole population in an area. Different indexing systems already exist for the various attributes of the delivery system. These provide a means of comparing different population groups within the system. The type of index developed and used will depend on the objective of the evaluation exercise. A careful examination of existing indices in use in health care delivery systems suggests that these can be categorised into three groups. Viz.: Health indices, Health -economic indices, and Socio-economic indices.

3.5.1 Health indices

These are indices that are used in evaluating the state of health of a population. Different indices are currently in use to evaluate different aspects of health.

1- The Disease Index

The disease index is more of an epidemiological entity, and is used to quantify and compare prevailing diseases in different areas or countries. In animal health, a table of disease indices for every country is produced annually in the FAO-OIE Animal Health Year book which also classifies all the reported diseases according to the FAO-OIE classification (AHYB, 1992). The indexing system simply allocates units (+), to countries according to the level of each prevailing disease in that country. The disease indices can become a useful tool for providing economic information for the various reported diseases. It is important to note that the economic value of a disease for a practice or a country may not correspond to the relative importance of the disease based on the FAO-OIE classification, but rather the client perception of the disease. McInerney (1996) suggests a possible re-classification of livestock diseases based on their economic rather than veterinary characteristics.

2- Quality Adjusted Life Years (QALY) Index

This is an index which measures health in terms of quality adjusted life-years especially in humans. This involves computing a quality-of-life score which is a form of utility score, utility deriving from the fact that the level of well-being influences the ability to provide for oneself (Culyer, 1989). The QALY score is calculated by weighting each remaining year of life by the expected quality of life in each year.[1] The efficiency of service delivery would then be measured by the sum of the QALY for the whole population. Under such circumstances, health care policy objectives would be to maximize the QALY for the whole population. It is suggested that health maximization using QALY may result in inequity of resource allocation (Wagstaff 1991, Bleichrodt, 1997). Harris and Nease (1997), criticized QALYs calculations for not discriminating between values due to co-morbidities and that due to the index condition (principal disease). QALY is particularly criticized for discriminating against older people (Johanesson and Johansson, 1997). The difficulty of developing similar index in animal health emanates from the fact that livestock are seldom kept until old-age, and contrary to the situation in human health, older animals would be valued higher than younger animals, but the objective is seldom to prolong life expectancy.

3.5.2 Health economic indices

These are indices derived from economic analysis employed in evaluating health care interventions. Such economic analysis include: Cost-effectiveness analysis (CEA), Cost-benefit analysis (CBA), Cost-utility analysis (CUA) and Cost of Illness analysis.

1- Cost-of-illness values.

This index, rather than just measure the level of disease in a population as in disease index, provides an index of the economic value or monetary cost for a disease in an individual or population. It often includes the direct cost of treating the disease as well as the indirect costs attributable to production loses from the illness. This index which is widely used in human health, provides a means of undertaking a cost-benefit analysis of disease control programmes even in animal health. There is quite

[1] Life expectancy has been used as an index in health care in some studies, suggesting the targeting of different age-groups of the population (Johansson, 1996).

clearly the difficulty of including indirect costs in the evaluation of the Cost-of-illness analysis especially in human health (Ratcliffe, 1995).

2- Cost-Utility Analysis

Economic analyses of available health care such as Cost-Utility Analysis (CUA) have been developed using related quality of life measurements (Dolan et al, 1996). CUA compares the costs of a health care programme with its benefits and measures the impact of the disease control programme on the length and quality of life years.

3- Cost-effectiveness analysis (CEA)

Here, the monetary value of an intervention is compared to the physical effect of disease averted by the intervention (Weinstein, 1990, Johannesson 1996, Gold et al, 1996). Thus, it is possible to compare the money to disease (death) values of two or more alternative interventions.

4- Cost-benefit analysis (CBA)

Cost-benefit analysis, unlike cost-effectiveness analysis, compares the monetary cost of interventions with the monetary value of the benefits derived from implementation of the intervention (Johannesson, 1996). In either case, the efficiency of interventions are being measured, and a comparison made possible by the analysis.

3.5.3 Socio-economic indices

Most socio-economic non-disease related characteristics especially of the human population within a health care delivery system, often result in nominal categories for which metric indexing is in-appropriate. These often involve special indices generated to provide a picture of particular areas of policy interest. For instance, useful index commonly generated is that of the level of resources available to the health care consumer. In particular, poverty indices have proved useful, where equity of access is being evaluated. In similar vein, level-of-well-being index is often required in certain epidemiological studies where predisposition to diseases is related to well-being. Poverty indices in human health are related to the amount of income or household consumption associated with acceptable minimum levels of nutrition (Carvalho and White, 1997). Poor livestock producers on the other hand, are described as those who produce at subsistence level and are economically and socially vulnerable (Heffernan and Sidahmed, 1998). Whether in human or animal health, it is quite often difficult to agree on empirical values for indexing poverty, despite the usefulness of the index. More often however, income levels are simply ranked and grouped in quintiles from the highest quintile (top 20 percent or richest), to the lowest quintile (lowest 20 percent or poorest).

3.6 Geo-spatial models in health care delivery

The spatial characteristics of populations vis-à-vis location of health care facilities have been identified to influence access to health care. The development of geo-spatial models have simplified the otherwise complex problem of analyzing the spatial characteristics of populations. Hitherto, most geo-spatial activities have been limited to "cataloguing, projection and display" of socio-economic and health care variables so as to permit comparison across regions (Delehanty, 1992). Geographical Positioning System (GPS) machines permit accurate geo-referencing of populations and facilities under study, while Geographical Information System (GIS) computer software programmes allow data management and display. The development of search and optimization models, such as location-allocation models, permit a more rational decision making process on the question of the optimum location of facilities in view of the spatial distribution of the population. With regards to health care, Location-allocation (L-A) models are classified as either "Context free" (i.e. relating to no specific application) or EMS Systems models (i.e. emergency medical services system) (Revelle et al, 1977). Irrespective of the type of application involved, L-A models may have one of several objectives, such as minimizing aggregate travel distance for a population or maximizing coverage (facility usage).

It has long been recognised that, the problem of equity and access to facilities for any population is a function of the location of the population in relation to the facility they use (Hodgart 1985, Rushton, 1988). Location-allocation models address the problem of locating facilities such that they are as accessible as possible to the population, by allocating population centres (demand points) to their nearest facility (supply points). The models use as input data, the co-ordinates of the population centres and those of the existing or planned facilities, the population figures, any existing road network as well as the production or socio-economic coefficients of each population unit. Depending on whether the objective is to minimise the aggregate travel distance or maximise attendance (usage) of the facilities, the models can compute the aggregate travel distance (cost) by the whole population, the mean travel distance (cost) and the proportion of total population allocated to each facility within any specified distance ring. The output data from the location-allocation models can be manipulated in a decision analysis, using coefficients derived from population sample surveys to produce appropriate indices for evaluating different aspects of health care service delivery (Revelle et al, 1977).

3.7 Decision support modeling of health care services.

Determining health care indices for a population is only of importance when used in the decision-making process, and particularly when accurately dis-aggregated within the population. This will provide a better picture of how the particular health care variable is distributed within the various segments of the population. Such objective is now achievable through the use of geo-spatial models. The concept of Precision Service Delivery (PSD) even goes further, and involves the development of hybrid models, which combine the results of the geo-spatial models with econometric models resulting in decision support tools which permit more efficient targeting of health care interventions (Christiansen, 1985, Birkin et al, 1996). Hitherto, health care, and in particular, animal health care models have been either econometric in objective or addressing causal relationships (Ngategize and Kaneene, 1985, Dijkhuizen, 1988).

3.8 Implementation and dissemination policy decisions

When the economic values of alternative interventions are available, it is then possible to choose and implement the most efficient and cost-effective intervention (Andrews and Johnston, 1985). Quite often, the outcome of analysis would need to be disseminated in one reporting form or the other. These constitute the final step of the PSD framework.

3.9 Using PSD in the evaluation of privatisation policy

The principal working hypothesis of this study is that *"the adoption of privatisation policy reforms, in the delivery of animal health services in Africa, will have adverse economic and social impact on the various stakeholders"*. Deriving from this principal hypothesis however, is the minor hypothesis addressed by this chapter, which attempts to develop *"the possibility of accurately evaluating the efficiency of delivery of animal health services under"* policy scenarios as described in the principal hypothesis above. In other words, the PSD framework will be used in this study to evaluate the feasibility and the impact of privatisation of animal health care delivery in Zimbabwe.

3.9.1 Essential concepts and theories

Before attempting to determine the feasibility of private practice in any area, it is important to understand certain relevant economic concepts and theories relating to the demand for animal health services. During privatisation, demand can be defined as those services that livestock producers or owners of companion animals in a particular area, are willing and able to pay for, as well as those services the government or NGOs are inclined to pay for due to their public good characteristics (Maddock, 1987). Supply on the other hand, are those financially self-sustaining (viable) veterinary personnel or facilities in a particular area, which provide the services demanded by livestock producers or others, at prices above cost. A practice is thus said to be viable, only when existing demand is greater than practice income aspiration (Odeyemi, 1993).[2] Demand in this study derives from the current and potential uptake of veterinary services by farmers, while supply is represented by services received from animal health personnel or facilities located closest to the farmers. Uptake can be measured either in terms of the number of veterinary visits received by farmers, or farmers expenditure on veterinary services, drugs and input. Whatever the method used in measuring uptake or demand, it is often necessary to be able to use the same units to compare the various livestock types and numbers owned by different producers in that area.

Such a measure of aggregation, is the Animal Economic Unit (AEU), which can be defined as; *"the number of livestock owned by a producer, measured in terms of the monetary equivalence of one indigenous cow in the area"*. The use of the monetary value of the animal, permits us to evaluate production systems in which the value of the livestock (to its owner), is not in the amount of meat produced alone. This is in recognition of the fact that, the willingness of producers, or owners of companion animals, to pay for veterinary services, depends on the value they place their animal. The advantage of this measure over Animal Unit or the Tropical Livestock Unit (TLU) which values animals in terms of kilogram weight of meat, is that, even the value of pet dogs and cats, or draft animals which are not used for meat can be measured here (Konczacki, 1978, Sanford, 1983).

[2] Income Aspiration represents the amount in monetary terms that a veterinarian, paraveterinarians or practice, would want to earn, over and above the cost of providing the services, such as rent drugs and travel (etc).

3.9.2 Establishing the variables of animal health care services

In order to establish the feasibility or otherwise of private veterinary services in an area, a number of variables (indices) of animal health service delivery need to be computed.

1- the wealth of the farmers, measured in AEU

2- the total veterinary expenditure of the farmers and government in the area

3- the size of the practice area (in km squared)

4- the distribution (number and location) of veterinary personnel or facilities

5- the income aspirations of the veterinary personnel or practices.

To establish the wealth of livestock producers as well as their level of veterinary uptake, a questionnaire will need to be administered to producers.. Similarly, a questionnaire will need to be administered to any existing animal health care providers in the area to help provide a measure of their income aspirations and of the size of their practice areas.[3] The unit of demand is the Veterinary Economic Unit (VEU), defined as livestock producers' Total Veterinary Expenditure (measured in monetary value), per Total Animal Economic Unit owned. The VEU (or total Veterinary Expenditure) within the practice area of a veterinary practice, will be compared to their Income Aspirations to establish the Practice Viability Index (PVI) of the various practices in the area (Odeyemi, 1993). As stated earlier, practices with PVI greater than one will be considered viable, and only such practices will survive privatisation. Consequently, only livestock within the practice area of such financially self-sustaining facilities will be covered following privatisation. If the viability of different areas for private practice can be established, then the level of veterinary coverage in the country can be established, and the impact of the health and economic impact of the privatisation policy will be determined.

[3] The average Income Aspiration of the various cadres of health providers as provided by the survey, will be used, where private practices exist. However, estimates from the salary structures of government personnel will be used where private practices are not in existence. An estimate of running costs as well as incentive to leave government service will have to be added to the per annum income.

3.10 Conclusion

In addition to dwindling financial resources, the most important problem encountered by planners involved in the delivery of health care services has been the difficulty of quantifying and qualifying the demand for such services, and consequently, resources are inadequately allocated to meet these demands resulting in poor uptake of otherwise well intended and potentially beneficial policy initiatives. The concept of Precision Service Delivery (PSD) involves the five step process of qualifying, quantifying, dis-aggregating, rationalising and disseminating data and information relating to a delivery system.

In agreement with the principal working hypothesis of this chapter, this procedure, through a combination of tools, can provide a means of resolving many resource management problems as relating to the delivery of animal health care services in Africa and other developing countries. The different measures of demand from the allocated population will be derived from surveys and other statistical analysis conducted on the sample population. When applied to the output of the location-allocation model, more informed decisions can be made with regards to the population under study. This case study will involve the followings:

1- A questionnaire survey of livestock producers in Zimbabwe, conducted with a view of identifying any prevailing socio-economic stratification within their animal health delivery system

2- Indices of health care uptake such as veterinary expenditure and veterinary coverage will be quantified for any identified categories of production system.

3- Existing animal health care facilities will then be evaluated in terms of their efficiency of location and allocation using the L-A (geo-spatial) model.

4- Equity issues relating to the economic impact of a privatisation programme will be investigated using results of the L-A modeling exercise. It is also possible to evaluate issues relating to the viability and sustainability of existing health care facilities using a decision analysis model.

5- The results of the analysis showing the impact of various privatisation policy scenarios will then displayed using GIS.

CHAPTER 4

SOCIO-ECONOMIC DETERMINANTS OF LIVESTOCK PRODUCTION SYSTEMS AND ANIMAL HEALTH CARE UTILISATION IN ZIMBABWE.[1]

4.1 Introduction

With the current privatisation policy, there is an increasing need to be able to accurately quantify and qualify the demand for animal health services in most developing countries, and in particular, Sub-Saharan Africa. Under this dispensation, an increased participation of the private sector in the delivery of animal health services is expected, while livestock producers are to bear more of the costs of the services they receive. The ability and willingness of producers to pay for services hitherto provided free by the governments has therefore come under greater scrutiny. While it is widely accepted that the two producer characteristics, the ability and willingness to pay, would affect uptake of privatised services, very little research has been conducted on how these relate to veterinary uptake in the context of the different livestock production systems in Africa. In view of the diversity inherent in the livestock production systems in Africa, many believe that the ability of the different production systems to participate in any major policy initiative such as privatisation is likely to be varied. For instance, it now seems widely accepted that, with privatisation, poor and rural livestock dependent populations within extensive production systems are likely to be less able to pay for services. This, it is argued, will result in less access for the poor producers who will be disadvantaged and further marginalised by the policy. A similar situation has been studied in parts of Africa for human health (Bolduc, Lacroix and Muller, 1996). Establishing a means of evaluating the existence of this phenomenon, as well as developing a framework for improved services and information to farmers and advisers, with respect to demand for animal health services is the objective of this study.

[1] Modified version of a paper presented at the Ninth International Conference of Institutions of Tropical Veterinary Medicine, Harare, Zimbabwe. 14th - 18th September 1998.

4.2 Background

It is now pertinent for planners to be able to establish the role of the various livestock production characteristics in the demand for veterinary services. Initial work on the subject suggests that the demand for veterinary services and hence work available to a veterinary practice in an area is not only dependent on the prevailing and threatening diseases alone. The economic characteristics and distribution of the livestock and companion animal population in the area as well as other factors relating to the socio-political and geographical characteristics of the area are thought to influence demand for health care services (Odeyemi, 1996b, Odeyemi, 1998d). Other than the prevailing diseases therefore, the characteristics of the livestock production systems are perceived by earlier workers to dictate the uptake of introduced animal health initiatives in most developing countries (AGREF, 1986, Freeland et al, 1990, Doyle, 1992, Gros, 1994, Omore et al, 1997). Several techniques currently exist for quantifying and qualifying the population of livestock in an area, as well as the distribution of prevailing diseases (de Leeuw et al, 1995). Secondary data is readily either available in some published form, or can be gathered in most countries. However, techniques for characterising the livestock population, and the relevant data, especially as they relate to veterinary uptake, are not available. This makes the task of quantifying and qualifying demand for veterinary services in a country or region difficult.

In general, it is thought that livestock production systems in developing countries fall into one of four broad categories based on their ecological or socio-economic characteristics (Freeland et al, 1990, Macpherson, 1995, Sollod and Stem, 1991, Gros, 1994, de Leeuw et al, 1995, Omore et al, 1997)[2]:

- System 1. Nomadic or transhumant pastoral systems.
- System 2. Small-scale mixed farming systems.

[2] There are different types of livestock production systems within these broad categories. For instance, de Leeuw et al (1995) described three different types of production systems involving cattle within the traditional sector of agriculture in SubSaharan Africa. Maeda-Machang'u et al (1995) on the other hand, described three categories for the same sector of agriculture for Tanzania alone. These are by no means exhaustive as other systems involving other livetock types also exist.

- System 3. Extensive ranching systems.
- System 4. Intensive husbandry systems (dairy, poultry, piggery etc.).

In the absence of specific studies providing quantitative evidence on veterinary uptake for these production systems, it is speculated, probably by observing the distribution of existing spontaneous private veterinary practices in Africa, that private sector involvement in the delivery of animal health services though varying between production systems, would be more successfully introduced and most beneficial in the market oriented Systems 3 and 4, and less so in Systems 1 and 2 which are usually smallscale, extensive and subsistence in nature (Freeland et al, 1990, Omore et al, 1997).[3] The above suggests therefore, that the uptake of the privatisation policy in any country will be related to the prevailing livestock production systems in that country (Gros, 1994). Furthermore, the presence of large intensive livestock production systems are thought to encourage private sector delivery of animal health services.[4] On the other hand, extensive livestock production systems are perceived not to be attractive to private sector participation. Despite a near universal acceptance of this phenomenon, very little work has been done to test the hypothesis.

The working hypothesis that has emerged from the above is that, *"the uptake of a privately delivered animal health service will be influenced or indeed determined by the prevailing livestock production systems in the country or region"*. However, an attempt to adequately understand the relationship between the prevailing livestock production systems in Africa and veterinary uptake in the context of privatised services, further raises a number of other research questions.

1- What are the putative determinants characterising livestock production systems in Africa and how can these be quantified?

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[3] Carlin and Crecink (1979) found that using the two concepts of defining small farms, low volume of business establishment and low level of economic well-being, may result in farms switching categories, as well as requiring differences in policy focus and interventions.

[4] Levels of health care demanded is thought to depend on production goals, with types and levels of offtake being the principal determinant (de Leeuw et al, 1995, Gitau et al, 1994a,b).

2- Do the production systems differ significantly on the basis of these variables and to what extent does each variable contribute towards characterising the production systems?

3- On the basis of the putative variables, can a rule-base be found for allocating membership to the existing livestock production systems and is it possible to predict veterinary uptake on the basis of any relationships that can be derived from the variables?

Using relevant statistical techniques, the above research hypotheses was tested as it related to existing livestock production systems and veterinary uptake in Zimbabwe.

4.3 The study

4.3.1 Methodology

The framework for the statistical evaluation of the various working hypotheses in this study involves the following steps:

1- The development of a null and alternative hypotheses.

2- The choice of relevant statistics to test the null hypotheses.

3- Data collection

4- Data analysis

4.3.2 The Null Hypothesis

As stated earlier, the main working hypothesis is that, *"the uptake of a privately delivered animal health service is determined by the prevailing livestock production systems in the area"*. From this broad hypothesis can be derived, three related minor research hypotheses and their corresponding null hypotheses:

Research Hypothesis 1: The putative characteristics (derived from the literature) contain and can be reduced to a number of useful dimensions of the production characteristics.

Null Hypothesis 1: *There are no distinguishable (useful) dimensions to the putative production characteristics.*

Choice of statistics: The most appropriate statistical test would appear to be the Principal Component Analysis both from the point of data reduction as well as the identification of the structure contained within the putative variables. This will however be preceded by a descriptive summary of the putative variables and a non-parametric analysis of variance.

Research Hypothesis 2; The different categories of livestock production systems can be distinguished on the basis of these identified dimensions.

Null Hypothesis 2: *The different livestock production systems cannot be classified using the identified dimensions of the putative variables.*

Choice of statistical test: Discriminant Analysis is the choice of statistical test for this hypothesis.[5]

Research Hypothesis 3: The level of uptake of veterinary services is dependent on certain characteristics of the livestock production systems.

Null Hypothesis 3: *The demand for veterinary services by the various production systems can not be predicted on the basis of some identified unique dimensions.*

Choice of Statistics: Multiple Regression Analysis was used for predicting demand in this case.[6]

4.4 Statistical Analysis : the theoretical basis

4.4.1 Principal Component Analysis (PCA)

This is a form of Factor Analysis whose main purpose is to summarise the information contained in a set of variables. All the variables are considered simultaneously in relation to each other and the analysis results in the transformation of variables into a new set of variates which maximise the explanation of the entire set. There are three main objectives for the use of this technique:[7]

1- Identify the inherent dimensions (structure of relationships) among variables.

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[5] Because data to be analysed is collected on the basis of existing predetermined categories of production systems, Cluster analysis is less appropriate as a test for this hypothesis, hence the choice of Multiple Discriminant Analysis.

[6] Other workers have used the method of Maximum Likelyhood Estimates to predict demand for health care (van de Ven and van der Gaag, 1982).

[7] Lafi and Kaneene (1992) described studies using a possible fourth objective for PCA, that of detecting and correcting for multicollinearity amongst a group of variables before further predictive analysis.

2- Data reduction by identifying representative variables (surrogate variables).

3- Create a new set of variables, to replace original for use in subsequent analysis.

The basic assumption of the test is that there is an underlying structure within the variables, resulting in significant levels of correlation between several variables. On the other hand, statistical assumptions required by the test are those of normality, homoscedasticity and linearity.[8] There are three steps involved in Principal Component Analysis (PCA):

1- Computing the correlation matrix for the variables being analysed.

2- Obtaining a factor matrix (contribution of each variable to the newly derived factor).

3- Extraction of the significant factors depending on the accepted level of the Eugene value.[9]

The variability (variance) of the Principal Components (PCs) progressively decrease from one to the next, with the first PCs being responsible for most of the variances between the variables. Each PC thus represents a dimension, made up of the contributions of various variables. The correlation between the canonical variables and the PCs allows one to determine which particular variables contribute the most to any particular PC. Various rotational techniques exist which transform the loading onto fewer (one or two) variables within each PC, thus allowing the ease of selecting a representative variable for each PC. It is then possible to reduce the number of variables to be used for further analysis by selecting the representative variables for the extracted PCs as the surrogate for the entire set of dimensions and hence variables.

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[8] Homoscedasticity refers to the assumption that dependent variables exhibit equal levels of variance across the range of predictor variables. Multicolinearity is assumed for this test as the identification of the interelated variables is part of the test objective. Normality is however required only if significance test is to be applied.

[9] The Eugene Value provides the explanatory powers of each component (factor), and this is equal to the sums of squares of the factor loadings within each component. Several criteria exist for the number of factors to extract (See Hair et al, 1995 , Everitt and Dunn, 1991)

4.4.2 Multiple Discriminant Analysis (MDA)

This is a test used principally to establish a rule for allocating membership to known groups, and has applications in situations where the primary objective is to identify the group to which an object belongs. Other objectives include the following:

1- Determine whether statistically significant difference exists between the average score profiles on a set of variables (metric) for "a priori" defined (non-metric) groups.

2- Determine which of the independent variables account the most for the differences in the average score profiles.

3- Establish procedures for classifying statistical units into groups on the basis of their scores on the independent variables.

4- Establish the number and composition of dimensions of discrimination between groups formed from the set of independent variables.

The technique of MDA operates by deriving a variate that will best discriminate between "a priori" defined groups. It is particularly appropriate for testing the hypothesis that the group means for a set of independent variables (metric) for a number of groups (non-metric) are equal. This it does by computing a composite discriminant score from all the variables in the analysis for each individual. It then compares this score with that of the group centroid.[10] If the variance between the groups is large relative to the variance within the groups, then the discriminant function is said to separate the groups well. A new object can thus be classified by calculating its discriminant function and seeing which group mean it is closest to. The test of significance of the discriminant function is a measure of the distance between the group centroid. The MDA is based on assumptions of multivariate normality of independent variables, absence of multicolinearity and elimination of outliers.[11] The test is often validated by dividing the sample into an analysis and

[10] MDA maximises the variance between the groups and minimises the variance within them.

[11] Multicollinearity refers to the correlation among three or more independent variables. It reduces the predictive powers of individual independent variable to the extent of its association with the other variables, thus masking useful predictive relationships (Lafi and Kaneene, 1992).

hold-out groups. The discriminant function is developed using the analysis group while the hold-out group is used for validation.[12]

4.4.3 Multiple Regression Analysis (MRA)

Regression analysis is used to predict the value of a dependent variable (criterion) from the values of one or more independent variables (predictors). It permits the determination of the relative importance of each independent variable in predicting the dependent variable. The regression coefficient (*b*) is the slope of the straight line that provides the best index of association between the predictor and criterion variables. It allows comparison between coefficients as to their relative explanatory power. The standard error gives the accuracy of the prediction. The Multiple Correlation Squared (R^2) is also called the coefficient of determination, and is the proportion of variation in the criterion (dependent) variable accounted for by the linear combination of predictor (independent) variables, and the level of statistical significance is tested by the f-ratio. The adjusted R^2 takes into account the number of predictor variables. The greater the R^2 the greater the explanatory power of the equation. Regression analysis is based on the assumptions of normality, linearity and homoscedasticity.

4.5 Research design

4.5.1 Study area

This study was designed to permit a statistical characterisation of the various livestock production systems in Zimbabwe on the basis of their utilisation of health care services. A stratified, cross-sectional survey was conducted, with the various production systems being the target population[13]. Categorisation into different production systems is based on existing classifications as indicated in government census documents and other published sources of secondary data. Mashonaland East

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[12] A split of 60-40 or 75-25 is recommended depending on the sample size.

[13] A cross-sectional (one-time) survey technique is perceived to be adequate for this study. Information covering a one-year time period was required to take care of seasonal variations (Dong et al, 1998). Most animal healthcare activities within a one-year period are properly documented by commercial farmers, and can be vividly remembered by even the non-commercial farmers.

Region, one of nine regions in Zimbabwe constituted the sampling (area) frame, and the relative proportion of the different production systems informed the numbers of producers interviewed for each producer category[14]. Because this survey is a pilot study especially aimed at developing and testing methodologies, emphasis was not placed on absolute sample populations (Cox and Cohen, 1985). Notwithstanding, a total of 145 livestock producers were interviewed in the following proportions: 67 Communal farmers, 58 Small scale / Resettlement farmers, 9 Commercial livestock /game farmers and 11 Commercial agro-livestock (mixed) farmers.[15]

The questionnaire designed for the various production systems were similar and simple to encourage response (Appendix 3.1). The questions were designed to extract information on the types and location of the producers, their socio-economic characteristics as well as their uptake of animal health care services. While the commercial producers received their questionnaires by mail (with self addressed return envelopes), the non-commercial farmers had their questionnaires delivered physically, and oral interviews conducted by nominated Veterinary Extension Officers (VEOs).[16]

4.5.2 General Assumptions

In the design of this study, a number of very important assumptions were made. They relate to issues which will facilitate the research process without adversely affecting the results or the conclusions made.

1- Since all the cases studied come from the same province, disease prevalence is assumed to be similar across the production systems.

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[14] Stratification ensures that the different categories are covered in the appropriate proportions using the probability of occurrence as reflected in various secondary information sources.

[15] The communal and smallscale /ressettlement farmers are non-commercial, while the livestock-game and agro-livestcok producers are commercial farmers.

[16] The VEOs are familiar with the farmers and the veterinary activities in the study area. They can thus enhance the accuracy of the response both by clarifying the questions and preventing exaggerations by any unscrupulous respondent.

2- Provider types are perceived to be similar, thus quality of services would be uniform (i.e. no difference between services provided by professional and para-professional personnel).

3- Competition is perceived to be non-existent, while cost of services are uniform between producers.

4- Demand is here assumed to be elastic, although one point data collection is involved (partial equilibrium).

5- Statistical assumptions (such as normality) were made for the data set and corrected where deemed appropriate.

4.5.3 Demand for veterinary services

The demand for veterinary services is thought to be synonymous with veterinary uptake. In human health care delivery, demand has been described as deriving from the interaction between the demand function for health or utility, and production function of health or investment (Grossman, 1972, Grossman, 1982, Muurinen, 1982). Health care demand can therefore be defined in terms of the following variables: doctor-patient visits, expenditures for drugs and hospital admissions (van de Ven and van der Gaag, 1982). The absence of a hospital admission equivalent, especially in livestock health care delivery, means that there are two widely used indicators of veterinary uptake; veterinary coverage and producer veterinary expenditure. Veterinary coverage refers to the proportion of animals in an area served (treated) over a specified period. For most reports, the number of animals treated per year as well as the frequency of treatment would seem to be indicative of veterinary uptake[17]. Deciding on the unit of veterinary coverage is thus a major source of problem. While some farmers would consider the regular visits to the dip tank as treatment, others would only consider actual administration of medications either orally or parenterally (injection). In either case, the measure would yield

[17] In a survey situation, this variable is difficult to represent and quantify due to the range and frequency of activites that constitute treatment occasions. For instance, activities such as dipping, or conditions requiring repeat treatments are likely to confound the results. Unfortunately, the effect of seasonality in treatments mean also, that time frames have to be a major consideration with study periods of one year being most acceptable.

widely varying results especially as most treatment occasions would be difficult to recall. The scale of this problem may be reduced by using the number of visits by the veterinarian or his assistant to the farm, or visit by the farmer to the veterinary clinic as the measure of veterinary coverage. For this purpose, repeat visits to treat the same group of animals for the same or different conditions are considered as additional visits. Although veterinary visit does provide a useful guide to demand for veterinary services, it neglects those services provided by the farmers themselves. Unfortunately, for rural farming communities who might have less access to veterinary facilities, the treatment they administer themselves constitutes a high proportion of animal health services for the farm (Odeyemi, 1994b).

The second index of veterinary uptake is the producer veterinary expenditure, which represents the amount spent on veterinary services over a specified period. Money spent on services by the veterinarian could be separated, but should preferably be combined with those spent by the farmer on purchase of veterinary drugs from the pharmacy[18]. This way, the variable appears to resolve the problems of the other indices by covering all veterinary activities both by the clinician and the farmer. Furthermore, farmers would normally have a better re-collection of how much they have spent over the past year when required to do so. To the private practitioner, veterinary expenditure is a more useful index as it represents potential practice income. However, veterinary expenditure as an index of veterinary uptake creates a problem of its own, especially with regards to the comparative analysis of herd characteristics. Total veterinary expenditure is likely to be strongly correlated with herd size, hence larger farms would score higher than smaller farms within the same production system and may therefore not characterise the production system, but rather the herd size. This problem can however be resolved by deriving another variable, expenditure per livestock unit from the total veterinary expenditure. This derived variable reflects the relative veterinary expenditure within the production

[18] Veterinary expenditure is said to increase with greater herd size. Wise (1988, 1987) reports that larger livestock herds spend proportionately more on health products and proportionately less on services than do owners of smaller herds.

system, irrespective of the size.[19] On the whole, it is considered that the various dimensions of veterinary uptake and hence demand for veterinary services would be covered by using both variables, veterinary visit and expenditure per livestock unit (veterinary expenditure).[20]

4.5.4 Characteristics of livestock production systems

The livestock production systems in Africa are inherently diverse both between and within regions and indeed countries. Little (1984) set out socio-economic indicators which constitute a framework for the study and characterisation of pastoral livestock production systems in Africa. They include:

1- Identification of the appropriate unit of production (e.g. herd size).

2- Ownership and distribution of livestock /wealth.

3- Economic diversification such as other income activities like cropping etc.

4- Local resource management such as land tenure system, and political administrative influences.

5- Spatial and temporal dimensions (e.g. location and movement).

6- Terms of trade for the producers such as production objectives and levels of commercialisation.

7- Articulation with national or regional economies (i.e. influence of surrounding commodity markets)

Several of these characteristics of livestock production systems are adduced to influence their over-all behaviour with regard to demand for veterinary services in

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[19] A second problem however, is that any prevailing subsidy programme within the delivery system would influence any indexing system based on farm veterinary expenditure. It is assumed however that prevailing subsidies, just like prevailing diseases, would be the same for the different production systems in any one area, region or country.

[20] It is important to note here that, although both variables are supposed to provide a measure of veterinary uptake and hence demand for veterinary services, it is unlikely that both measures would provide similar results in all analyses. This is because each measures a different dimension of veterinary uptake and therefore has different units, one monetary and the other non monetary, and may therefore behave differently. For instance, an increase in demand for veterinary services is expected to be depicted by increased veterinary visits as well as increased veterinary expenditure. However, subsidy in a delivery system would promote an increase in veterinary visits, but would lead to a reduction in recorded producer veterinary expenditure.

general, and privatised services in particular. These putative characteristics are thought to be either economic or non-economic in nature, and are responsible for the ability and / or willingness of a producer to pay for services. Thus, the various determinants involved can therefore be grouped into two categories;

1- Economic factors.

- Herd economic characteristics.

2- Non-economic factors.

- Prevailing politico-geographical factors.
- Intrinsic farmer socio-cultural characteristics.

The herd economic characteristics relate to the economy or wealth of a production system, and are thus likely to influence its ability to pay for services. Factors that comprise this group include herd-size, breeds of livestock kept as well as the types and levels of offtake (Doran et al, 1979). The willingness to pay for a service on the other hand, is thought not to be related to wealth but determined by the farmer's perception of the services on offer (Sullivan et al, 1996). Perception, though intrinsic to the producer, is likely to be a product of his socio-cultural, political and geographical experience (Guerin and Guerin, 1994). People of similar socio-cultural backgrounds are therefore likely to have similar perceptions of the same health service (Rahkonen and Takala, 1998).[21]

Thus, willingness to pay is expected to differ between, but be similar within production groups. The politico-geographical factors of production systems are those which relate to the spatial distribution of the various production systems relative to existing political and economic institutional infrastructure (Filson, 1996). This is exemplified by prevailing government policies on livestock production and animal health, as well as the organisational structures of the relevant government departments. Factors covered here include prevailing land tenure systems, animal

[21] Osunade (1993) noted that while utilitarian principle forms the strong basis for perceptions, "cultural block" is often responsible for a lot of the perceptions informing decisions on the uptake of agricultural initiatives. McGregor et al (1996) found that maintenance of their "way of life" ranks higher than profit maximisation as an objective for farmers.

health and production policies as reflected by prevailing subsidies, and the relative access to existing veterinary infrastructure and the resultant consumer satisfaction. Overall, intrinsic farmer characteristics resulting from prevailing socio-cultural experiences are thought to inform and form the farmers perception and hence his attitude towards change or accepting new technologies or introduced initiatives (Baker, 1974, Behnke, 1985, Simpson, 1984, Swift and Toulmin, 1992).

4.5.5 Herd economic characteristics

The economic characteristics of a livestock production system are often perceived to be related to the types of livestock kept, the size of the units and the types and level of offtake (livestock sold) derived from the herd (Simpson, 1984, de Leeuw et al, 1995).[22] In addition to these individual variables, two derived variables are created, one to aggregate the total livestock unit of the farm and the other to aggregate the total offtake from the farm. These ensure that it is possible to compare offtake in different herds irrespective of the combination of livestock types kept.[23] For the purpose of analysis, offtake is presented as a percentage of total livestock size being considered. This ensures that the level of offtake is not influenced by absolute herd size. The modified ratios of livestock as presented in chapter two, Animal Economic Unit (AEU), is used to compute the livestock units.[24]

Another economic variable not related to the herd but often adduced to influence economic decision making within a production system is the presence or absence of other sources of income. This occurs in various forms such as mixed farming,

[22] For the purpose of the questionnaires, variables were created for the numbers of the different types of livestock known to be kept in the study area (viz. Cattle, Sheep and Goats, Pigs, Poultry etc.). Variables for the levels of offtake for each livestock type are also provided (Viz., Cattle sold, Pigs sold, Poultry sold etc.).

[23] The real economic value of a livestock sold is recognised to vary between different production systems (Behnke, 1985, Doran et al, 1979, Scoones, 1992). The use of farm-gate prices for subsistence farmers is viewed as an under-estimation (Gittinger, 1982).

[24] One Animal Economic Unit (AEU) equals to 1 Cow, 2 donkeys, 1 horse, 2 pigs, 10 Shoats (sheep and goats), 100 Chicken, 1 Ostrich and 20 Turkeys (Computed from 1996 market values of livestock in Zimbabwe). The AEU unlike the livestock unit (LU), represents the actual monetary value of the animals as percieved by the producers. However, Animal Units will be referred to throughout this analysis as LU.

trading, paid labour and family remittances. The complexity of this variable is compounded by the reluctance of farmers in some cases to admit to having additional sources of income, and in most cases, to reveal the value of the income. The difficulty of differentiating between the different sources and in determining the economic values of additional incomes, inform the use of a single binary variable (Other income), to represent this characteristic in any analysis.[25]

4.5.6 Socio-political and geographical factors

Quite often, livestock production systems are influenced by factors that arise as a result of the location they find themselves, either in terms of the physical geography of the area or the political infrastructure. For instance, the organisation and distribution of the veterinary infrastructure such as clinics, dips, abattoirs etc. are often based on the political administrative districting prevalent in the country. Thus, access to veterinary facilities are indirectly linked to the political decisions as to where to establish clinics, rather than the actual demand for the facility. Significantly therefore, regional or district health centres are located at the district or regional headquarters, which quite often are the biggest towns or cities in the area. Thus access to such facilities would be linked to the relative distance of the farms to these centres. The distance between the farms and their nearest clinic, depicted by the variable Clinic distance, would provide an insight into how access relates to clinic distance.[26]

Consumer satisfaction for animal health services would normally be expected to be related to quality of services and access, hence proximity to the facilities. Because the measure of satisfaction is rather subjective, similar levels of satisfaction are

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[25] While the presence of other sources of income might be perceived to enhance the economic status of a production unit, it should be realised that more often than not, this variable is a characteristic of less commercial type of production systems and may therefore, contrary to expectations, be negatively correlated to wealth (Jackson and Collier, 1991, Wanmali, 1992).

[26] It is important to note here that, while smallscale farmers would be referring to the Animal Health Management Centres close to them, respondents from commercial farms are likely to be referring to the District Veterinary Clinic or private Clinic farther away in the nearest city.

unlikely to be given the same rating by different respondents.[27] It is therefore safer to settle for a binary variable, Satisfaction, either one is satisfied or not.[28] Other aspects of service delivery such as policies on subsidies would equally be related to the political administration governing the area where a livestock facility is established. It may therefore be necessary to establish the prevailing level of subsidy in an area so as to be able to determine how this influences veterinary uptake as well as to relate other variables. An ordinal variable Getfree, with four increasing categories reflect different levels of subsidy from zero subsidy, to subsidy in advice, epizootic vaccinations and even privately inclined clinical services, allows the prevailing subsidy level to be quantified and analysed against other variables.

The distance between farms and their nearest city creates a multi-dimensional variable, Citydistance. Between different production systems in a country or region, Citydistance may provide an indication of the land tenure system. It aggregates the distance between different production systems and the existing cities, thus in countries with tenure policies such as resettlement and other segregation programmes, the effect of such policies on veterinary uptake are readily highlighted. A second and more general dimension of the relative distance between farms and cities occurs both between and within different production systems, where it is a reflection of dualism.[29] Livestock production systems are sub-systems of larger regional economies. Changes in regional economic settings of other sectors are therefore likely to have significant impact on the endogenous variables of production units (Little, 1984). Thus proximity to such regional economic activities or centres is expected to influence production activities and patterns as well as producers' perception of introduced initiatives (Kjaer, 1994). Levels of veterinary uptake are perceived to be influenced positively by proximity to urban centres, with this effect

[27] Wise (1987) found positive attitude towards the veterinarian to be positively related to herd veterinary expenditure.
[28] A possible difficulty with this variable is that, the farmers might not wish to be seen to be criticising their service providers, especially where as in this case, the local VEOs were the ones conducting the questionnaires.
[29] Dualism describes a co-existence between a "primitive" and a more "modern" economic system, resulting in the latter influencing the former.

fading as one moves away from the centres. The effects of proximity to urban areas may be a reflection of better and more favourable economic infrastructure such as better market outlets or better commodity prices both of which are perceived to promote veterinary uptake (Huhn, 1990). The specific and direct contribution of markets were not specifically tested in this study.[30]

4.6 Results

4.6.1 Descriptive Summary

The four production systems have been described in terms of fourteen different variables as derived from the literature. Table 4.1a provides a comparative descriptive summary of the variables derived from the respondents as they relate to each production system.

Table 4.1a

Descriptive Summary of some Socio-Economic Indicators for the Four Recognised Categories of Livestock Production Systems in Zimbabwe.

	Communal Farmers		Smallscale/ Resettlement		Commercial livestock/ game		Commercial Agro-livestock	
	Mean	S.E	Mean	S.E	Mean	S.E.	Mean	S.E
Cattle Numbers	12.46	1.63	27.76	2.43	272.63	93.14	391.18	72.39
Dairy Cattle	.06	.05	.28	.28	65.13	62.14	2.18	1.46
Equine Numbers	.09	.06	.38	.19	7.22	3.86	2.55	1.38
Sheep & Goats	5.79	.90	6.74	1.14	96.67	62.21	32.00	14.33
Pigs Numbers	.39	.16	9.02	6.53	44.44	44.44	13.18	13.18
Poultry Numbers	35.06	4.70	39.62	6.69	69.56	38.10	76.18	51.57
Pets Numbers	2.63	.31	2.98	.25	5.11	.89	6.18	1.14
TLU	14.37	1.79	34.52	4.09	464.68	179.91	410.07	69.96
Cattle Offtake %	8.72	1.60	18.25	1.53	28.06	5.41	26.64	6.27
Vet. Expenses (Z$)	173.52	40.41	250.78	37.99	15282.00	7197.00	21587.10	11284.18
Willing to Pay (Z$)	210.78	60.24	294.48	37.88	16474.31	7847.30	25450.81	11284.18
City Dist. (km)	75.34	7.07	130.59	6.94	39.56	5.91	58.45	9.23
Clinic Dist.(km)	11.39	1.06	12.55	1.31	33.67	3.63	36.00	5.84
No. of Visit by vet.	3.76	.45	8.96	1.19	8.89	2.71	4.50	.76

However, because a lot of secondary data categorise these production systems only in terms of their commercial objective (viz. Commercial and Non-commercial), a second analysis was done. Table 4.1b provides a comparative descriptive summary

[30] It is important to note however that, a possible confounding factor exists. Veterinary facilities such as clinics are usually located in high human population centres such as cities and big towns. A correlation observed between city distance and veterinary uptake may thus be due in part to the fact that clinics are more likely to be built in cities.

aggregating the same information into just two production systems, based on whether they are commercial (Commercial livestock/ game and Commercial Agro-livestock) or non-commercial (Communal and Small-scale/ Resettlement).

Table 4.1b

Descriptive Summary of some Socio-Economic Indicators for the Different Categories of Livestock Production Systems in Zimbabwe based on Commercial Objectives.

	Non-Commercial Farms		Commercial Farms	
	Mean	S.E of Mean	Mean	S.E. of Mean
Cattle Numbers	19.92	1.61	344.16	57.56
Dairy Numbers	.16	.13	28.68	26.20
Equine Numbers	.22	.10	4.65	1.91
Sheep & Goats	6.23	.71	61.10	29.11
Pigs Numbers	4.39	3.04	27.25	20.91
Poultry Numbers	37.18	3.99	73.20	32.33
Pet Numbers	2.79	.21	5.70	.74
TLU	24.19	2.37	434.64	87.11
Cattle Offtake %	13.37	1.19	27.22	4.19
Vet. Expenses (Z$)	208.99	26.58	18784.83	6355.18
Willing to Pay (Z$)	248.62	37.26	21461.66	7063.34
City Distance (KM)	100.97	5.54	49.95	5.99
Clinic Distance (KM)	11.93	.83	34.94	3.53
No. of Visit by Vet	6.17	.64	6.58	1.40

The Kruskal-Wallis One-Way Analysis of Variance was used to test the means of the variables for the different livestock production systems using the two methods of categorisation (Table 4.2). In general, there appears to be significant difference between the means of the variables for the different production systems irrespective of the method of categorisation. However, for both methods of categorisation, the Mean value for the Sheep and Goats, as well as Pigs kept by the different production systems do not seem to be significantly different. On the other hand, the mean value of Poultry kept is significant only when considering categorisation on the basis of commercial objectives, while Veterinary Visit is significant only when considering the four putative categories.

4.6.2 Testing Null Hypothesis 1: Principal Component Analysis

Fourteen putative production characteristics were subjected to Principal Component analysis as a means of testing the first Null Hypothesis, that no identifiable dimensions exist to the characteristics. That the test was appropriate was confirmed by both the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy (MSA) and the Bartlett Test of Sphericity (Table 4.3a).[31]

Table 4.2

Kruskal-Wallis One-Way Analysis of Variance Comparing the Means of the Variables Using the Two Different Criteria for Categorising Production Systems.[32]

	Putative Farm Types* (Four Categories)		Commercial Objectives** (Two Categories)	
	Chi-Square	Significance	Chi-Square	Significance
Cattle Numbers	65.9055	.0000***	39.0588	.0000***
Dairy Numbers	44.2891	.0000***	30.3840	.0000***
Equine Numbers	20.2518	.0002***	16.8617	.0000***
Sheep & Goats	.0138	.9996	.0123	.9118
Pig Numbers	.5090	.9169	.0127	.9101
Poultry Numbers	10.2621	.0165	8.0765	.0045***
Pet Numbers	20.3708	.0001***	17.5154	.0000***
TLU	72.5557	.0000***	46.3130	.0000***
Cattle Offtake %	62.6278	.0000***	31.4625	.0000***
Vet. Expenses (Z$)	54.9529	.0000***	46.6610	.0000***
Willing to Pay (Z$)	54.2569	.0000***	45.8173	.0000***
City Distance (KM)	39.3308	.0000***	11.0695	.0009***
Clinic Distance (KM)	37.3264	.0000***	37.0314	.0000***
Visit by Vet.	22.3199	.0001***	.6321	.4266

*Putative Farm Types (Communal, Smallscale /Resettlement, Commercial Livestock /Game and Commercial Agro-livestock Farms).

**Farm Types based on Commercial Objective (Commercial and Non-commercial farm types).

*** $P < .05$

Extraction of dimensions was based on the Rule-of Thumb by Everitt and Dunn (1991), which suggests a cut-off point of Eigen Value 0.7. Factors with loading less than the cut-off point are not considered. On the basis of this, eight factors (dimensions) and their corresponding surrogate variables were extracted (Table 6.3b). This was facilitated by the use of the Oblique Rotation Method (Oblimin capability of the SPSS Software)[33]. Consequently, eight dimensions and eight surrogate variables free of multicollinearity are identified for use in further analysis.

[31] Bartletts Test of Sphericity and KMO's measure of sampling adequacy both confirm presence of inter-correlation amongst variables (Hair et al, 1995). KMO measure >.7 is considered adequate.

[32] A non-parametric ANOVA technique was chosen based on the data type being analysed.

[33] Factor rotation involves turning of the reference axis about its origin. It results in the redistribution of the variance of the earlier factors to later ones in order to obtain a more meaningful array of factors. Where several variables are similarly loaded for the same factor, rotation results in redestribution such that only one or two factors emerge (For detailed discussion, see Hair et al, 1995).

Table 4.3a
Description of Variables Entered for Principal Component Analysis:

Variable	Communality	Variable	Communality
CITYDIST (Distance to Nearest Cityt)	1	LGPEROFT (Log of Percentage offtake)	1
CLINDIST (Distance to nearest clinic)	1	OTHERINC (Other income sources)	1
GETFREE (Subsidy received)	1	SATISFY (Satisfaction with services)	1
LGCAT (Log of Herdsize of cattle)	1	INCRFEES (Attitude towards payment)	1
LGTLU (Log of Total Livestock Unit)	1	LTWTP(Log Willingness to Pay value)	1
LGTOTEXP (Log Total Vet. Expenditure)	1	DAIRY (Number of dairy cattle owned)	1
LGOTHLU (Log of Other Livestock kept)	1	WANTFREE (Services wanted free)	1

KMO Measure of Sampling Adequacy: 0.71906
Bartlett Test of Sphericity: 893.633 Significance: .0000

Table 4.3b
Summary Result of Principal Component Analysis: Extraction Criterion.

Factor	Eigen Value	Percent Variance	Cumulative Percent	Dimensions Extracted**	Surrogate Variable
1	4.789	34.2	34.2	Wealth	LgTotal LU
2	1.508	10.8	45.0	Satisfaction	Satisfy
3	1.439	10.3	55.3	Supplementation	Otherinc
4	1.111	7.9	63.2	Location	Citydistance
5	0.999	7.1	70.0	Intensification	Dairying
6	0.916	6.5	76.9	Diversification	Lg Other LU
7	0.797	5.7	82.6	Commercialisation	Lg Percent Offtake
8	0.719	5.1	87.7	Attitude	Willing-To-Pay
9	0.570	4.1	91.8		
10	0.480	3.4	95.2		
11	0.312	2.2	97.4		
12	0.287	2.0	99.5		
13	0.063	.4	99.9		
14	0.008	.1	100		

**Factors with Eigen values < 0.7 not extracted as per Everitt and Dunn (1991).

4.6.3 Testing Null Hypothesis 2: Multiple Discriminant Analysis (MDA)

The one hundred and forty five cases (respondents) were randomly split into two groups, an "analysis" group (60 percent of cases) and a "hold-out" group (40 percent of cases)[34]. The "hold-out" cases are to provide a "cross-validation" group for the discriminant functions derived after and MDA test is performed on the "analysis" group (Hair et al, 1995). The surrogate variables representing the extracted dimensions to the characteristics of the livestock production systems, are then used in a MDA to test the second Null Hypothesis. The hypothesis infers that, identified dimensions cannot be a basis for classifying the different livestock production systems in Zimbabwe. A MDA test performed on both the "analysis" and the "hold-out" group of cases resulted in the correct classification of 76 percent and 68 percent

[34] Random split generated by "Split-Case" command in SPSS software.

respectively, into their appropriate livestock production systems (Table 4.4a and Table 4.4b).

Table 4.4a

Multiple Discriminant Analysis Classification Results for "Analysis" Group of the Four Livestock Production Systems in Zimbabwe.

Actual Group	No. of Cases	Predicted Group 1	Predicted Group 2	Predicted Group 3	Predicted Group 4
1- Communal	44	79.5%	20.5%	0%	0%
2- Smallscale /Resettlement	31	19.4%	80.6%	0%	0%
3- Commercial Livestock	4	25.0%	25.0%	25.0%	25.0%
4- Commercial Agro-Lives.	7	0%	14.3%	14.3%	71.4%

Percent of "grouped" cases correctly classified: 75.74%
Box's M[35] = 107.088 Significance =0.000

Table 4.4b

Multiple Discriminant Analysis Classification Results for "Hold-out" Group of the Four Livestock Production Systems in Zimbabwe.

Actual Group	No. of Cases	Predicted Group 1	Predicted Group 2	Predicted Group 3	Predicted Group 4
1- Communal	23	78.3%	21.7%	0%	0%
2- Smallscale /Resettlement	27	29.6%	66.7%	3.7%	0%
3- Commercial Livestock	5	0%	0%	20.0%	80.0%
4- Commercial Agro-Lives.	4	0%	0%	25.0%	75.0%

Percent of "grouped" cases correctly classified: 67.80%

Table 4.5a

Multiple Discriminant Analysis Classification Results for "Analysis" Group Livestock Production Systems in Zimbabwe (Categorised on Commercial Objective).

Actual Group	No. of Cases	Predicted Group 1	Predicted Group 2
1- Non Commercial	75	100.0%	0%
2- Commercial	11	27.3%	72.7%

Percent of "grouped" cases correctly classified: 96.51%
Box's M = 186.58 Significance =0.000 (Test of equality of covariance matrices)

This is considered as an acceptable level of accuracy, resulting in the rejection of the Null Hypothesis in this case. A similar MDA test performed to classify the same split samples into categories based on production objectives (viz. commercial and non-commercial), resulted in even a higher level of accuracy, 97 percent and 98 percent respectively for the "analysis" and "hold-out" groups (Table 4.5a and Table 4.5b). These results suggest that, although it is possible to accurately classify livestock producers in Zimbabwe into their four putative production categories using the extracted dimensions, such classification is likely to be easier and more accurate if

[35] The Box's M Test is a test of equality of covariance matrices. Unequal co-variance matrices can adversely affect classification.

the criterion is based on the two-class commercial objective. Table 4.6 provides a greater insight into the relative influence of each extracted variable in the discriminant functions, as well as how each function is responsible for separating the production categories.

Table 4.5b

Multiple Discriminant Analysis Classification Results for "Hold-out" Group Livestock Production Systems in Zimbabwe (Categorised on Commercial Objective).

Actual Group	No. of Cases	Predicted Group 1	Predicted Group 2
1- Non Commercial	50	98.0%	2.0%
2- Commercial	9	0%	100.0%
Percent of "grouped" cases correctly classified:		98.31%	

Table 4.6

Interpretation of Structure Matrix of Multiple Discriminant Analysis of the Four Livestock Production Systems in Zimbabwe.

Discriminant Function	Percent Contribution	Contributing Variable[1]	Group Separation
Function 1	79.92%	- LgTLU*** - Lg OthLU - LgPerOft	Grps 1,2 from 3,4
Function 2	18.01%	- CityDistance*** - OtherIncome - Satisfy	Grps 1,3,4 from 2
Function 3	2.07%	- Dairy*** - IncrFees (WTP)	Grps 1,4 from 2,3

[1]Variables listed in descending order of correlation to Discriminant Function.
***P < .05

The variables contributing to discriminant function one, contribute nearly 80 percent of the separation observed and are particularly responsible for separating groups 1 and 2 from groups 3 and 4. On the other hand, variables responsible for discriminant function 2 separate group 2 from the rest, with a variable contribution of about 18 percent. Separation of groups 1 and 4 from groups 2 and 3 is achieved by discriminant function 3 with variable contribution of only 2 percent.

4.6.4 Testing Null Hypothesis 3: Regression Analysis

The third group of hypothesis relates to the question of whether or not, the demand for veterinary services by livestock producers in Zimbabwe can be predicted on the using these identified and extracted dimensions (surrogate variables). The Null Hypothesis suggests that this is not possible. Testing this hypothesis involves the use of the extracted surrogate variables in predicting two demand variables, Veterinary

Coverage (LgVetVisit) and Veterinary Expenditure (LogExPerLU) in separate stepwise regression analysis.[36]

Table 4.7a

Multiple Regression Estimates of Demand Variable: Veterinary Coverage (LogVetvisit).

Variables	Regression Coeff.	Standard Error	t- Statistics	Significance-t
CityDistance	.003032	.001044	2.903	.0043***
LogOthLU	.131008	.043526	3.010	.0031***
LogPerOft	.152157	.068170	2.232	.0272***
OtherInc	.411037	.163525	2.514	.0131***
Dairy	.003014	.112451	.039	.9691
IncrFees	-.020630	-.021627	-.255	.7991
LogTLU	.133227	.112451	1.334	.1843
Satisfy	-.051156	-.053672	-.634	.5273
Constant	.348100	.304745	1.142	.2553

***	$P < .05$
Sample Size	145
Overall F	7.04191
Significance F	.0000
Adjusted R^2	.14371

Table 4.7b

Multiple Regression Estimates of Demand Variable: Veterinary Expenditure (LogExpLU).

Variables	Regression Coeff.	Standard Error	t- Statistics	Significance-t
CityDistance	-.005077	.001216	-1.374	.0001***
IncrFees	.241621	.106885	2.258	.0255***
LogPerOft	.220603	.080455	2.742	.0069***
Dairy	-.105143	-.115350	-1.374	.1716
LogOthLU	-.149358	-.162760	-1.952	.0530
LogTLU	.000018	.000189	.002	.9982
OtherInc	.079104	.083657	.993	.3223
Satisfy	-.086699	-.091968	-1.093	.2764
Constant	1.984103	.242181	8.193	.0000***

***	$P < .05$
Sample Size	145
Overall F	9.94713
Significance F	.0000
Adjusted R^2	.15711

Note

The signs for Citydistance are different in the equations for Veterinary Coverage (+ve) and Veterinary Expenditure (-ve). This is probably due to the influence of the corresponding values of the two dependent variables for Small Scale Resettlement production system which is differentiated from other production systems by its relatively larger CityDistance value (see Table 4.6)

[36] It was deemed appropriate to undertake a log transformation of both dependent variables, as both were shown not to be normally distributed.

Of the eight independent variables (dimensions) entered into the stepwise regression analysis to predict the dependent (demand) variable, Veterinary Coverage, only four variables (CityDistance, LogOthLU, LogPerOft and OtherInc) were significant at $P<.05$ (Table 4.7a). The stepwise regression analysis to predict the second demand (dependent) variable, Veterinary Expenditure, resulted in only three of the independent variables (CityDistance, IncrFees and LogPerOft), being significant at the $P<.05$ (Table 4.7b). Note that the Coefficient of Determination (R^2 values) in both regression analyses are low. This is not unexpected in socio-economic studies of this nature. This is suggestive of the fact that, there are other factors not entered in this equation which also contribute to the dependent variables being predicted (Johnson and Bhattacharya, 1992). In this instance, only 14 percent and 15 percent of the covariance is explained by the dimensions in the equations represented by Tables 4.7a and 4.7b respectively.

4.7 Discussion and conclusions

This study arose as a result of the need to identify the factors that influence the ability and willingness of livestock producers to pay for veterinary services. In particular, it was adduced that producers in extensive production systems are likely to be less able and unwilling to pay for services, thus suggestive that certain production systems encourage greater uptake while others do not. This led to the development of three research hypothesis, the analysis of which resulted in the rejection of the three corresponding Null hypotheses being tested, while the alternative hypothesis were accepted. On the basis of this study therefore, the followings can be extrapolated to the livestock production systems in Zimbabwe:

1- There are distinguishable dimensions to the characteristics of the livestock production systems.

2- These dimensions can be used in classifying the different production systems.

3- The demand for veterinary services for the various production systems cannot be predicted on the basis of the levels of some of these dimensions. The dimensions established for the variables characterising the livestock production systems in Zimbabwe are as follows:

1- Wealth : this primarily represents herd size and those variables whose values are directly related such as, total expenditure and total monetary value of future expenditure for services.

2- Satisfaction: perception of current level of services being received.

3- Supplemental income: an indication of the presence or otherwise, of additional sources of income.

4- Location: this describes the spatial distribution of production systems in relation to urban centres. It may be a proxy for dualism or land tenure.

5- Intensification: modernisation represented by the level of dairying.

6- Diversification: the involvement of the producer in the production of other livestock species in addition to cattle.

7- Commercialisation: measures the level of monetarised herd economy (commercial offtake).

8- Attitude: this measures the inclination of the farmers towards accepting innovations, in particular, privatisation.

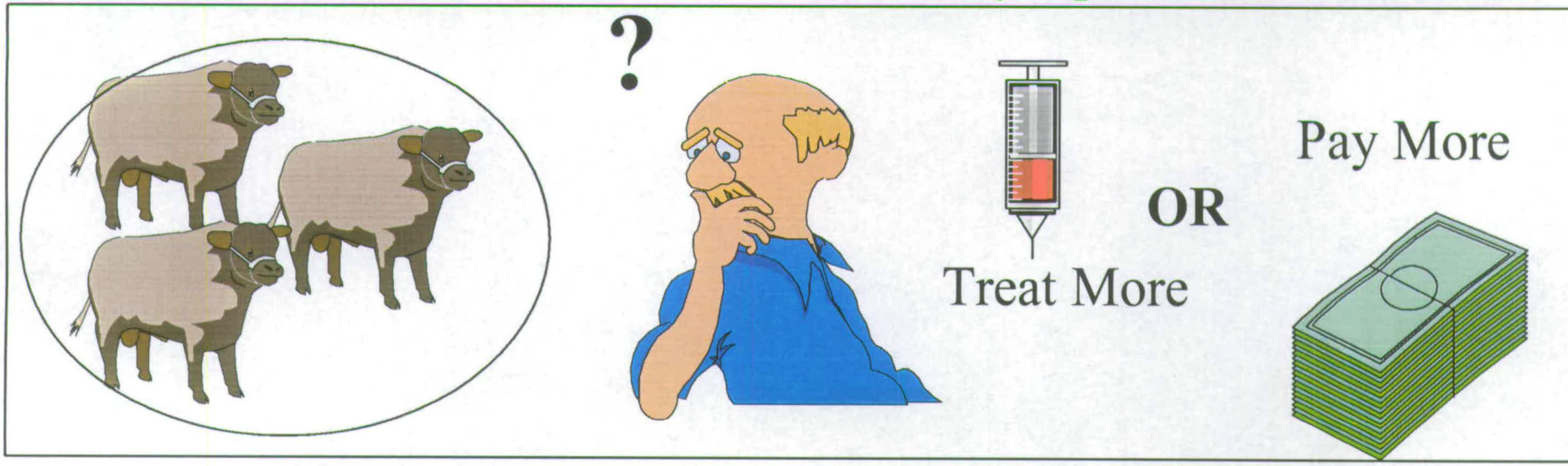
This study suggests that in Zimbabwe at least, there is a significant difference between the various production systems when viewed in terms of the identified socio-economic dimensions. Furthermore, the results of the discriminant analysis indicates that the identified dimensions permit a fairly accurate categorisation of the four traditional production systems. A better insight into the dimensions was possible due to the ability to view the livestock in terms of whether they are commercial or non-commercial producers. It then emerged that it is easier to predict the group membership of a producer using the commercial objective classification as opposed to the traditional production system grouping.

The principal hypothesis of this study however, is that the prevailing production systems dictate the demand for veterinary services, and that commercial production systems favour privatisation. The first part of this research hypotheses can therefore be tested in this study by attempting to establish whether those variables or dimensions that contribute heavily towards categorising the different production systems also contribute significantly towards predicting uptake? The results of the discriminant analysis shows that Wealth (80 percent), Location (18 percent) and Intensification (2 percent) are the three main dimensions that are significant in categorising the various producers into their respective production systems (Table 4.6). Apart from Location which accounts for only about 18 percent of classification achieved, other dimensions which are influential in characterising the production systems are not significant in predicting either indicators of uptake, Veterinary Coverage and Veterinary Expenditure (Table 4.7a and Table 4.7b). Furthermore, the rather low Coefficient of Determination in both regression equations suggest that there are other factors in addition to those in the equation, contributing to veterinary uptake.

The second part of the hypotheses relating to the viability of private practices under different production systems require a closer examination. The study shows that there is no significant difference between the commercial producers and their non-commercial counterparts in terms of the number of visits they make to or get from their veterinarians. However, the veterinarian expects to see 18 times more animals per herd visit, and earn 90 times more income from commercial farms than non-commercial farms. The spatial dynamics of the delivery of animal health services in Zimbabwe reveals other factors which are likely to influence the ability of each production system to sustain a private practice. In Zimbabwe for instance, the dip tanks constitute points at which animals, especially, non-commercial type congregate several times a year. An average of 2,029 animals visit each dip tank about twenty two times annually (Dip Tank Survey, 1996). At Z$17,444 per diptank (Z$8.64/TLU), each diptank provides similar income levels as commercial herds (Z$18,785). Considering that the nature of services demanded by commercial producers is often more specialised and costly, these results suggest that, other things being equal, it may be more profitable to visit a collection of non-commercial producers (e.g. at a cattle market or dip tank location), than it is to visit a commercial farm. It is therefore expedient to evolve strategies which will overcome the constraints imposed by the geographical location of the producers.

Figure 4.1.

<u>Livestock Producer Profile for Veterinary Uptake in Zimbabwe</u>



Farmers that Treat More

- Wealthy
- Have other sources of income
- Have favourable perception of existing veterinary services

Farmers that Pay More

- Closer to cities
- Have commercial objectives
- More willing to pay for clinical services

Since belonging to a particular production system does not necessarily guarantee a greater uptake of veterinary services, it therefore becomes necessary to look at individual farmer profiles to help predict uptake. The profiling of the producers permit an in-depth understanding of the factors that influence the behaviour of a potential consumer of a service or product, in this case veterinary services. In addition to the effect of land tenure policies in Zimbabwe, veterinary coverage was enhanced with producers who diversified, market more of their animals and have supplementary source of income. Furthermore, those farmers that spent more on their animals were those living closer to the cities, sold more of their animals than their peers within the same production system and have personal attitudinal inclination towards paying for services (Figure 4.1). From the above, it is safe to conclude that, the ability and or willingness to pay for veterinary services in Zimbabwe is not unique to any particular production system. The demands for services and the problems with uptake of any particular farming community therefore requires to be studied, understood and specifically targeted for any initiative to succeed.

This study highlights the significant roles of land tenure, livestock marketing and supplementary economic activities in promoting veterinary uptake. These dimensions of livestock production characteristics are therefore potential areas for policy interventions. It is recognised quite often, that the farmer's objectives and indeed perception are different from those of the planners, and this may influence his attitude towards introduced initiatives (Omore et al, 1997). However, intrinsic farmer attitudes may well be targeted by education and other extension activities to promote the benefits of any particular intervention which may otherwise be hindered by a lack of awareness or negative perception resulting from prevailing "cultural block" or indeed past experience. Overall, this chapter clearly shows that the success of any private practice is dependent on its ability to respond to the specific, and sometimes, changing user's needs (Fassi-Fehri and Bakkoury, 1995, Pritchard, 1991, Msolla, 1998).

CHAPTER 5

QUANTIFYING THE POTENTIAL DEMAND FOR PRIVATISED ANIMAL HEALTH SERVICES IN ZIMBABWE.

5.1 Introduction

The government of Zimbabwe currently subsidises animal health services to varying degrees to livestock producer groups, but, like several other African countries, now contemplates embarking on a privatisation policy. However, the behaviour of livestock producers and hence the latent demand for animal health services in Zimbabwe following the adoption of a privatisation policy by the government is not known. This has created a need for a technique to forecast potential demand through a cross-sectional observation of current consumption of animal health services by different producer groups. Where such a policy change is being contemplated, it becomes expedient to attempt to establish the values and functional relationships between existing and latent demand for services (Batie and Shabman, 1979). This will allow a better understanding of how providers of goods and services and in particular, how potential consumers will react to ensuing market changes (Jayne et al, 1996). An emerging research question, which constitutes the working hypothesis of this chapter is that, ***"demand for veterinary services will decrease with privatisation"***. This question will however be preceded by a secondary research question which relates to whether or not, economic value of the latent demand for privatised services can be computed. In other words, methodologies have to be developed for predicting demand for services with the implementation of privatisation policy.

A theoretical economic framework for evaluating such an evolving delivery system is suggested by Hardie and Strand (1979), that, the evaluation of economic benefits of public goods should be done within the framework of a partial equilibrium.[1] On

[1] Partial economic analysis assumes a "ceteris paribus" situation, that, only certain elements being analysed will change while others remain the same (Gittinger, 1982). In similar vein, Morris and

the other hand, evaluation of private or quasi-market situations would probably involve neo-classical economic approaches (Jones and Cullis, 1996). The conditions satisfying a framework for evaluating public goods would include the followings:

1- The theory of public expenditure which involves the utility maximisation problem, and assumes that the government provides only collective consumption goods, and ensures in the process, a "pareto-efficient" allocation (Samuelson, 1954).[2]

2- Measurement of "user-demand" functions, especially where existing goods are involved.

3- Contingent valuation methods which could be adopted where trade-offs between potential public goods do not match existing choice. Attempts can thus be made to determine an expressed true "willingness-to-pay" value for the goods or in this case services.

The body of literature on which the demand for health care is defined derives from the concept of Health-Investment or generalised Grossman Model (Grossman, 1972, Grossman, 1982, Muurinen, 1982). Grossman describes demand for health as deriving from "the interaction between the demand function for health and the production function of health. The model is based on the premise that, "state of health inherently deteriorates and requires investment to improve it". Hence, investment in health care results in two benefits, sustenance of life-span and utility, which relates to the consumption benefits of health. A lack of investment in health care on the other hand results in shortened life-span or a loss of utility. The apparent exclusivity of the two benefits in the original model has been criticised and corrected for in later models (Muurinen, 1982). The consumption (utility) properties of health care has attracted a lot of attention following privatisation of veterinary services.

Blood (1969) suggest partial farm budgets as a means of undertaking the economic assessment of veterinary services to livestock producers. Such an economic analysis for disease in a pig farm is provided by Rougoor et al (1996).

[2] Pareto efficient allocation assumes that the process of re-allocation of resources results in everyone being better off.

There is an extensive literature on the potential role of the public sector post privatisation, in the provision of those animal health services clearly of "collective consumption" type (Anon, 1993, Umali et al, 1992, Holden et al, 1997, Odeyemi, 1994, Freeland et al, 1990, Schillhorn van Veen and de Haan, 1995). These are those with externalities, or moral hazards and for which the producers may be unwilling to completely pay. Further more, the actual health care needs may be masked by the phenomenon of practitioner-induced demand (Hay and Leahy, 1982). However, the issue of identifying and quantifying the potential demand for privately inclined services, though pertinent to the privatisation debate in Africa, has received less treatment, especially as regards the thorny issue of viability and sustainability of services as well as matters relating to equity. This may be due in part, to the historical absence of a private practice culture and hence an absence of sufficient market information. On the other hand, the dearth of information may be traced to the absence of tested methodologies as well (Anon, 1993, Odeyemi, 1996). There are however, a number of approaches in other disciplines that can be adopted for quantifying latent demand for privatised services which were hitherto provided by the public sector, and for which market values do not exist. One such approach for valuing "extra-market" goods is the Travel Cost approach, which equates the value of a commodity or service to the cost consumers are willing to pay to travel to the service centre. Travel costs often under-estimate the true value of goods and services as they usually do not include the cost of time used for the travel. Furthermore, they also neglect changes in the quality and quantity of the services or goods which occur as demand and indeed distance increase (Bishop and Heberlein, 1979).

Contingent Valuation (CV) technique is another method developed for the measurement of "non-use" values, and aim at placing a value on "non-market" goods, such as the environment, natural resources or indeed other public goods for which true values are unknown. It involves extracting a willingness-to-pay (WTP) value from potential consumers, and equates this potential (hypothetical) "use value" to the price of the commodities. Maxwell (1994) differentiates between Option and Bequest values of WTP, which may have the effect of either increasing or decreasing the value placed on a good or service.[3] The CV technique utilises the market behaviour of people as a guide to both their preferences and the value they are willing to pay for goods. Often people are asked their current level of consumption of a good or service (revealed preference), or their expected purchase price of the good or service under a number of hypothetical prices (stated preference). Under this dispensation, potential demand is viewed to be synonymous with the WTP values extracted from the individual respondents and can be extrapolated to the whole population. In the context of privatisation, it is feared however, that the variety of services demanded and the potential clientele might change (Dinar, 1996). Critics of the technique further argue that, WTP responses are likely to be influenced by the inclusion of ethical views as well as other self interest preferences rather than actual economic considerations (Bishop and Heberlein, 1979, Phillips, 1997).[4] Because most CV surveys tend to involve hypothetical situations, and people are asked about commodities they may never purchase, it is suggested that CVM survey results need be combined with other information and experiences with usage, in reaching predictions on demand (Diamond and Hausman, 1993). Fox et al (1998) suggests increasing the precision of field survey by adjusting the elicited WTP using a calibration function derived by an experimental auction market technique.[5]

Economic calculations based on actual market evaluations of benefit-cost analysis, where such exists, can be considered to be an appropriate measure in CV techniques (Jayne et al, 1996). This may involve a hedonic pricing technique where measurement is made of demand for similar or related public or private goods, or their substitutes (Kridel, 1990, Coelli et al, 1991, Maxwell, 1994).[6] Under such

[3] "Option Value" is the amount individuals would pay for the opportunity to utilise a service or good in the future in addition to any possible current use. "Bequest Value" on the other hand, incorporates externalities as it includes possible use by others in the future.

[4] Public goods usually have free rider effects and this causes consumers to understate their WTP values. Furthermore, a rational consumer is expected to understate his preference in order to avoid the tax on it (Tiebout, 1956).

[5] This technique involves deriving a calibration function through a laboratory auction market bid for a subsample of the hypothetical survey bids. This function is then applied to adjust the actual WTP data.

[6] This is an indirect method involving estimating the value added for each activity within the upper limit of extracted WTP.

circumstances, it may be possible to use the information contained in the implicit prices of a market good to identify the demand relationship of the public good (Freeman, 1979). The use of stated preference techniques for evaluating market goods that are familiar to the respondents is perceived to be even more appropriate (Jayne et al, 1996). Measure of potential market for animal health services would seem to fulfil such a condition, and thus provide an appropriate area for the use of CV techniques. The CV technique is thus the method of choice in this study, especially in the light the inadequacies of the travel cost method earlier highlighted. There is precedence for the use of CVM techniques in the evaluation of potential demand for health care services (Phillips et al, 1997, Johnson et al, 1997). The WTP surveys however need to be carefully conducted to minimise bias. Health care literature contain other non-economic valuation techniques. Dolan et al (1996) compares the use of Standard Gamble (SG) and Time Trade-off (TTO) techniques. Both of them are based on the premise that the health utility function of an individual can be exchanged instead of money in WTP with either risk (of death) in SG or time reduction of life expectancy in TTO. However, since the current study focuses on economic (monetary) values, the method of WTP will be adopted. Other studies have utilised WTP (monetary) values to estimate the cost of particular illnesses under a number of hypothetical scenarios (Goddeeris, 1983).

5.2 Methodology

5.2.1 Research framework

The objective of the study is to estimate the total demand for privatised livestock health services in Zimbabwe.[7] The methodology adopted here involves the combination of stated and revealed preferences similar to work by Nestor (1998). An attempt is thus made to establish the national economic value (demand) of veterinary services by extrapolating from known herd-level veterinary expenditure data derived through cross-sectional studies (McInerney et al, 1992)[8]. The framework for the

[7] This study only evaluates services to livestock producers and in particular cattle. Services to pet and other companion animal owners are not considered here.

[8] Direct public expenditure resulting from various forms of subsidies as well as other indirect internal herd-level costs, such as farm household labour utilised during disease control are usually

methodology adopted is based on that recommended by McFadden and Leonard (1993), and involves the following steps:

1- Sample survey of the population.

2- Elicitation of WTP values for animal health services.

3- Sum-up "stated values".

4- Extrapolate values to entire population.

The assumptions made in the use of this technique are that the technique is reliable and that the stated preferences will coincide with true preferences. In general, there are two types of questionnaire techniques in use to elicit stated preferences:

1- Open-ended questions, where the respondent is simply asked to place a value (upper limit) on the good.

2- Closed-ended (dichotomous-choice) questions involve a simple yes or no, or a specified range of WTP options.

The elicited WTP values for the different producer groups can then be subjected to the following validity tests (McFadden and Leonard, 1993, Desvousges et al, 1993):

1- Psychometric robustness- sensitivity of WTP estimates to the types of questions asked.

2- Statistical reliability- stated values can be accurately extrapolated to the whole population.

3- Economic sense- stated values relate sensibly to prevailing economic variables such as herd size or wealth etc.

The choice of methodology should ensure that the above conditions are readily satisfied. For this study therefore, a modified dichotomous-choice method was adopted. Four incremental levels of choice were made available, as a percentage of current total level of veterinary expenditure by the respondents. The WTP value is

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not included in the expenditure figures derived by this technique (McInerney et el, 1992). Djkhuizen et al (1995) however suggest that national level economic analysis is not simply a process of summation of farm level economic analysis, but involve macro-economic principles.

thus expressed as a percentage of existing total budget as per technique by Kirkley (1975). This ensures that the CV technique is sufficiently robust and reliable.[9] The problem of "selectivity bias" does not arise here as every livestock producer is likely to utilise one form of veterinary service or the other. Meanwhile, "context effect" is perceived to be minimal as well, since the activity involved is a repetitive one and producers are very familiar with it.[10]

5.2.2 Questionnaire structure

The need to provide the respondents with sufficient information pertaining to the good or service, a condition for the reliability of the CV technique, has often resulted in rather extensive and quite often complicated questionnaire designs. Such questionnaires rather than ensuring reliability, often have the negative effect of "putting off" the respondents or indeed encourage biased answers.[11] For this study, a rather simple one page questionnaire design was adopted, which still contained all the essential components of a typical CV questionnaire. This was possible in this case because an extensive description of the services or the payment vehicle was not necessary as the target population were very familiar with the services and were already paying for some of these anyway. It was also necessary for the questionnaire to be made simple so as to appeal to, and be easily understood by, the majority of the respondents (smallscale rural farmers) who were barely literate and may resent extensive questioning due to their socio-cultural, and in the case of Zimbabwe, political background (Sollod and Stem, 1991).[12]

The questionnaire was designed principally to attempt to elicit the maximum amount respondents are hypothetically willing to pay for animal health services. The WTP

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[9] The survey technique when used by different analysts should yield similar results.

[10] Selectivity bias relates to the problem of not distinguishing between households (producers) that consume the service from those that do not. Context effect on the other hand refers to variations to stated preferences as a result of changes to the context of the choices presented to the respondents (Kridel, 1990, Hausman and Ruud, 1986).

[11] A lot of anomalous CV results are shown to be a product of faulty methodologies and in particular complicated questionnaire designs (See Mead, 1993, for detailed review).

[12] Despite nearly two decades of independence, Zimbabwean farmers, like the greater society, still reflect a black-white divide. Furthermore both societies are suspicious of each other, of the government and also of the outsider, especially when extensive questionning is involved.

values to be provided by the respondents was referenced to their current levels of veterinary expenditure. Thus, an earlier part of the questionnaire demands that the respondents state their current level of veterinary expenditure (revealed preference). Four WTP choices are then provided to respondents, These are incremental percentages, over and above their stated current veterinary budget (viz., 0%, 10%, 50%, and 100%).[13] This it was hoped will facilitate an understanding of the question, ensure that all the respondents have a uniform perspective of the question, and that the WTP values provided will be realistic and extreme responses are non existent. The problem of "strategic bias" was minimised by using the local veterinary extension officers to conduct the survey.[14] Other than the WTP section, an attempt was made in the rest of the questionnaire to identify and characterise the livestock producers. Additional information was thus requested on the location, herd size and structure, as well as other demographic and socio-economic characteristics of the producer. These would permit a characterisation of the production systems as well as allow other econometric analysis of the results to be undertaken.

5.3 Results

Although the information required from the respondents resulted in the elicitation of a percentage marginal willingness to pay value, it was possible to derive an absolute (total) willingness to pay value by converting the percentage information into monetary units and adding these to the stated current veterinary budget (veterinary expenditure per cattle). Table 5.1 provides the descriptive summary of the Percentage marginal WTP, the monetary equivalence of the Percentage WTP and the absolute WTP values for the four livestock producer types sampled during the survey.[15] Extrapolating the absolute WTP values for the various producer groups to the whole population would provide the potential value of the demand for a

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[13] A maximum of 100% set for the WTP choices was determined following the results of a pre-study survey of a small number of producers belonging to different groups.

[14] Strategic bias relates to the problem of the respondents trying to influence the results. If recognised before the survey, Nestor (1998) suggests correcting for this problem through the data collection technique.

[15] As in Chapter 4, this analysis is based on questionnaires from 145 respondents.

privatised animal health services in Zimbabwe.[16] A total potential annual demand (extrapolated total WTP value) for privatised animal (Cattle) health services of Z$ 113.96 million is thus projected for the whole country (Table 5.1). This is compared to estimated current demand of Z$98.48 million.

Table 5.1
Quantifying Potential Demand for Privatised Veterinary Services for the National Herd of Cattle in Zimbabwe Using the Total WTP Values.

Producer Types	Vet. Expenditure Per Herd (Zimb Dollars) Mean Value	Total WTP Per Herd (Zimb Dollars) Mean value	Value of Cattle Services (Mill.Zimb Dollars)	
			Current	Potential
Commercial Producers	18784.83	21,461.66	69.1	79.01
Smallscale Producers	208.99	248.62	29.38	34.95
Total			98.48	113.96

Note
Only cattle data is used in this analysis as the population and distribution of other livestock types are not readily available. Furthermore, they do not lend themselves to a clear commercial objective classification, as does cattle.

5.3.1 Validation of study technique.

The choice and design of this CV technique already ensures reliability and robustness. However, the test of theoretical validity still remains appropriate (Desvouges et al, 1993). For this test to be valid, the total WTP values elicited should show sensitivity to service usage. In other words, the total WTP values should increase for higher levels of service. Two simple tests were conducted to examine the theoretical validity of WTP values in this study:[17]

1- WTP values were tested for correlation with four indices of service usage which apply to and were provided by individual respondents; (Viz., Number of veterinary visits, expenditure per producer livestock unit, herd percentage offtake and average herd size). If this test is valid, the WTP values should be strongly correlated to these indices (as per Dolan et al, 1996).

[16] The cattle population of Zimbabwe comprise of 1.6 million heads of commercial cattle and 3.4 million heads of communal and smallscale resetlement (non-commercial) cattle. The Latent demand for services for the whole country is extrapolated from the total WTP per cattle for each of the two producer types (Expenditure ÷ TLU * Cattle Population).

[17] The choice of statistical technique was informed by the non-parametric nature of some of the variables. Maxwell (1994) used discriminant analysis and multiple regression for validating their CV technique, while Coelli et al (1991) used correlation and regression analysis.

2- The Kruskal-Wallis One Way Analysis of Variance test was conducted to establish whether there is any significant difference between the WTP values elicited for the various producer groups. For this test to be valid, the Chi-Square values should be significant for difference in service usage by the different producer groups.

Table 5.2

Test of Validity 1: Spearman Correlation Coefficient of Total WTP with Indices of Demand.

Indices of Demand	Correlation Coefficient	Significance
Veterinary Visit	.4723	.000***
Veterinary Expenditure (Per livestock Unit)	.7757	.000***
Percentage Offtake (Index of Commerce)	.6092	.000***
Herd Size (Livestock Unit)	.7145	.000***

Table 5.3

Test of Validity 2: Kruskal-Wallis One Way ANOVA for Total WTP and Other Indices of Demand of the Two Different Producer Categories in Zimbabwe.

Indices of Demand	Chi-Square	Significance
Veterinary Visit	.6321	.4266
Veterinary Expenditure (Per livestock Unit)	20.0230	.000***
Percentage Offtake (Index of Commerce)	16.7774	.000***
Herd Size (Livestock Unit)	46.3130	.000***
Total WTP	45.8179	.000***

In Table 5.2, all indices of usage showed positive, strong and highly significant correlation ($P < 0.001$) with the WTP values elicited, thus suggesting sensitivity of technique to service usage. The Kruskal-Wallis One-Way ANOVA test also shows a significant difference for the total WTP values, as well as for four of the five indices of demand for the different producer groups (Table 5.3). It can be concluded therefore, that the WTP technique used in this study has complied with the set validity tests.

5.3.2 Supply and demand profiling of animal health services

As an aid to the further understanding of the outcome of the privatisation policy, further empirical analysis was developed for this study. This involves the profiling of the various producer groups in terms of the levels of subsidies they received for animal health services during the year immediately preceding the survey, as well as the range of services they would want subsidised. This would permit the visualisation of the changes that are likely to occur in both the types and volume of services consumed by different producer groups following a withdrawal of subsidies. The animal health care services provided to agriculture are categorised into four incremental levels for the purpose of this study.[18] The questionnaire section on subsidy attempts to measure the level of government policy on subsidies for a range of health care services, while the question on services-wanted-free is to get an indication of the perception of the producers on a similar range of services. The method elected for this analysis is to simply cross-tabulate the response of the two categories of producers on the questions. The exercise will permit a comparative analysis relating to their current levels of subsidy as well as the services they would want to receive free.

The result of the analysis is summarised in Table 5.4a for the non-commercial producers and Table 5.4b for commercial producers. The impact column reflects the difference between the corresponding subsidised activity and the activities wanted free. A strong positive impact value is indicative of undue subsidy for an activity that producers are willing and probably able to pay for. Strong negative values suggest activities that producers will avoid if privatised or may not wish to pay for. Weak values of impact, whether positive or negative, are suggestive of indifference as in cases of activities which are already being paid for and would not be greatly influenced by a change in policy.

Table 5.4a reports a strong and positive impact for activity levels 2 and 3, which implies that non-commercial farmers are quite willing to pay for advice as well as

[18] Morris and Blood (1969) identified three activity levels for animal health services provided to agriculture, viz., Correction of sporadic occurences of disease in individual animals (privately inclined treatments), minimisation of risk (advice on control of zoonosis) and, planned prevention and control (vaccinations and ectoparasite control such as dipping). For this study, these activities were ranked according to the level of involvement of the veterinarian, and a fourth (zero) activity level added.

for vaccinations and tick control (dipping), despite being currently subsidised for both by the government. The huge and negative impact reported for activity level 4, is suspected to be an attempt by the respondents to influence policy towards further subsidy.

Table 5.4a
The Supply-Demand Profile of Animal Health Services
To Non-Commercial (Smallscale) Livestock Producers in Zimbabwe.

Activity Level	GetFree (%)	WantFree (%)	Impact (%)
Level 1 (None)	0	0.8	(+ve)0.8*
Level 2(Advice Only)	40.7	1.7	(+ve)39
Level 3(Advice + Vaccination/dipping)	50.8	28.0	(+ve)22.8
Level 4(Advice +Vacc/Dip + Treatments)	8.5	69.0	(-ve)60.5**

*Sign on value changes to (+ve) because of the effect of double (-ve).
**Impact value likely to be an attempt at influencing policy.

Table 5.4b
The Supply-Demand Profile of Animal Health Services
To Commercial Livestock Producers in Zimbabwe.

Activity Level	GetFree (%)	WantFree (%)	Impact (%)
Level 1 (None)	60.0	80.0	(+ve)20.0*
Level 2(Advice Only)	30.0	5.0	(+ve)25.0
Level 3(Advice + Vaccination/dipping)	5.0	10.0	(-ve)5.0
Level 4(Advice +Vacc/Dip + Treatments)	5.0	5.0	0

*Sign on value changes to (+ve) because of the effect of double (-ve).

Table 5.4b on the other hand, clearly reports strong and positive impact for activity levels 1 and 2. The result for activity level 1 suggests that up to 20 percent of respondents are currently being subsidised one way or the other even though they do not wish to be subsidised. The weak impact recorded for activity level 3 and the cancelling-out for activity level 4 confirms that the producers are already paying for those services anyway.

5.4 Discussion

In Africa and other developing countries, the policy of privatisation is being implemented without the benefit of a private practice culture and the accompanying market information needed in planning and decision making. The quest for some market information with regards to the setting up of privatised animal health delivery systems has led to the search for a technique, any technique, that will shed some light into the supply-demand economics of the delivery system. In such a scenario, the Contingent Valuation method becomes particularly attractive as a technique to elicit "market information" out of a potentially "non-market" situation.[19] Because of the hypothetical framework on which the technique is based, it is often criticised, and in some quarters rejected, as a scientific and reliable basis to make an economic decision. However, it has been shown that the value of the technique is contingent on the quantity and quality of information available to the respondents as regards the good (service) under study (Pate and Loomis, 1997). Thus, in the absence of more credible and feasible alternatives, and until sufficient market information can be collected using alternative techniques, collated and made available for the purpose of decision making, the CV technique shall continue to have a role in decision making. It has been shown that such a role will be appropriate and useful if care is taken in the design and implementation of the technique, especially where the population to be sampled are very familiar with the service and its provision and when the result of the technique is combined with other relevant information pertaining to the market and the good or service being studied (Diamond and Hausman, 1993, Jayne et al, 1996, Nestor, 1998).

Quantifying the latent demand for privatised animal health services in Zimbabwe has been attempted in this study using the CV technique. The results suggest an upper limit of about Z$114 million which represents a 15 percent increase over the current veterinary expenditure of Z$99 by the various producer groups in Zimbabwe. While this study does make a distinction between the contribution of various producer types to the total demand, no attempt was made to quantify the contributions of the individual services and products to either the current or latent demand, although this

[19] It can be argued that animal health services especially in developed countries have a clearly quantifiable market value for which more direct quantitative techniques are available. In Africa however, quantifying animal health services can only be by indirect methods due to the historical public delivery of the service resulting in the absence of market information, coupled with the non commercial offtake of livestock brought about by inherent diversities and socio-cultural idiosyncracies.

would be highly desirable. Thus the latent demand may include a potential for introducing new services and products, or the selective removal of subsidies on services hitherto provided by the government. The results of the empirical analysis on the profiling of producers with regards to the levels of services they are currently being subsidised or wish to be subsidised for, shows that all (100 percent) of non-commercial and smallscale livestock producers receive some form of subsidy or the other. This is in comparison to about 40 percent of commercial producers who are variously subsidised. Particularly significant to the privatisation policy is the fact that about half of the commercial producers who are currently receiving subsidies do not wish to be so subsidised. Even more interesting is the fact that, although most of the non-commercial producers indicate the need for one form of subsidy or the other, their increased WTP values suggest that they are actually willing to pay for more services than they are already doing. This suggests that although they would want to have subsidies, they are quite happy (willing) and able to pay for more services, suggesting an inappropriateness of the current levels and types of subsidy.

5.5 Conclusions and policy implications

These two exercises provide us with a basis for quantifying potential demand for privatised veterinary services in Zimbabwe as well as a better insight into the possible impact of any policy changes on the different producer groups in the country. On the basis of the results of this study, two general observations have emerged. Firstly, under certain circumstances, a total collapse of services to non-commercial producers can be avoided, as their veterinary expenditure may be able to sustain some form of privatised services.[20] Secondly, that with the ability to quantify and qualify the latent demand for services, comes the scope for proper planning and monitoring of policy changes to the delivery system. The above observations leads to a negation of the working hypothesis of this chapter, which states that, ***"demand for veterinary services will fall with privatisation"***. The alternative hypothesis is therefore recommended for adoption, as it relates to animal health care services in Zimbabwe.

[20] Variuos models of service delivery will be discussed in Chapters 7 and 8.

The major areas of impact for the commercial farmers relate to those activities (such as advice) that are likely to remain with the government even after privatisation. The projected potential demand would therefore involve an increased demand for the same products currently being consumed and for which payment is affordable and acceptable. Alternatively, newly introduced activities could feature in the list of consumed services depending on need, but without recourse to public funds in the form of subsidies. For the smallscale non-commercial producers, the index of impact is rather more diffused (evenly spread-out) and the types of services demanded redistributed. This suggests that the potential demand would be for a selective consumption of the various activity levels, depending on availability of the services, need and available resources. While it is obvious that the demand level projected for this group of producers would not permit their consumption of the same level of services with their commercial counterpart, withdrawal of subsidy as in privatisation would not necessarily result in the collapse of any particular service currently being consumed. Consequently, selective privatisation supported by targeted subsidy programmes for resource-poor producers or for activities with rather high externalities or moral hazards would be the appropriate policy thrust. Such an arrangement will ensure a more cost effective, efficient and equitable resource allocation and service delivery.

CHAPTER 6

GEO-SPATIAL MODELLING OF ANIMAL HEALTH CARE DELIVERY SERVICES IN ZIMBABWE.

6.1 Introduction

An integral component of the privatisation policy in Africa, is the restructuring of the hitherto government-operated animal health delivery systems. The policy involves budgetary cuts and the "downsizing" of existing veterinary infrastructure. In the majority of the cases, this is expected to lead to retrenchment of "surplus" staff as well as closure and/ or relocation of some existing facilities. A number of government veterinarians as well as new veterinary graduates would therefore be expected to go into private practice. These personnel would want to know which parts of the country would support self-financing private practices. The governments on the other hand, will in addition want to know which areas will require continued government support in the form of subsidies, where such is considered as an option. In either case, this will involve being able to quantify and qualify the demand for veterinary services in the different agro-ecological zones, and in the context of the diverse socio-economic conditions in the countries. This study addresses the issue of developing techniques to provide an empirical and therefore more informed and rational basis for planning as well as assessing already planned and on-going programmes. Of particular importance is the issue of equity and access to veterinary facilities, as well as the economic viability and sustainability of existing and planned facilities, especially where resource poor and often rural livestock producers are affected (Ayeni et al, 1987). This study is aimed at achieving the above through the analysis of the geographical distribution of existing animal health care facilities and resources in Zimbabwe vis-à-vis the demand for services and policy options being considered by the government. A number of research questions are addressed in the process:

1- How efficiently are the existing (or planned) veterinary facilities distributed in space, vis-à-vis demand for services?

2- What are the viability and sustainability considerations?

3- What equity issues arise from the existing or planned allocation policies?

This study aims to develop a universally applicable framework for the planning and implementation of the above policy objectives. In particular it investigates the locational efficiency of existing and planned policies on the allocation of clinical facilities and the equity issues that may arise as a result. The working hypothesis that this chapter seeks to address therefore is that:

> *"there is scope for improving the spatial distribution of existing or planned facilities of delivery of animal health services in Zimbabwe, thereby bringing about greater efficiency and equity of access as well as ensuring viability and sustainability".*

A number of Null Hypothesis derived from the above working hypothesis will form the framework for this study.

Null Hypothesis 1: *The spatial distribution of existing veterinary facilities in Zimbabwe is efficient with regards to access.*

Null Hypothesis 2: *The spatial distribution of existing veterinary facilities in Zimbabwe is equitable.*

Null Hypothesis 3: *Existing veterinary facilities in their current locations are not viable.*

6.2 Modelling Health Care Delivery

The utilisation of health care in a community is influenced by a number of factors which include the perception, availability, acceptability and affordability of the services provided (Fiedler, 1984). Utilisation occurs only when there is access, and the study of access provides a measure of potential utilisation. It has long been recognised that the problem of equity and access to facilities for any population is a function of the location of the population in relation to the facility they use (Pinch, 1985). While access is often associated with travel distance, Le Grande (1982) suggests that access might best be described in terms of the time and money costs that individuals incur in using health care facilities. Unfortunately, too many factors influence travel costs and travel time as measures of access. Hence, travel distance often suffice as a crude but standard and fairly repeatable measure of access. Dant et al (1990) showed that where choice is to be made between hospitals for inpatient care, location emerged as the second most important reason for the choice of a particular hospital. In rural and often resource poor populations with fewer choices, location thus becomes even more important. The utilisation of health care facilities has been shown to decline as travel distance by the population increases (Ingram, Clarke and Murdie, 1978). Thus, a population is perceived to have greater access the closer it is to a health care facility. This principle formed the basis for the development of different location-allocation models that are able to improve access to health care by minimising the aggregate travel distance (costs) or coverage for the whole population (Finnegan and Hodgart, 1995). Revelle et al (1977) distinguished between context-free location-allocation models which address general location-allocation problems and those models developed specifically for Emergency Medical Services (EMS). Since these models only exist for other industries, this study explores the possible use of location-allocation models in the animal health delivery system. Within the conceptual framework of Precision Service Delivery (PSD) earlier developed for the evaluation of animal health delivery systems, Location-allocation modelling constitutes the essential tool needed to accurately desegregate available demand for services, thereby permitting the possibility of accurate targeting of interventions (Chapter 3).

Equity of access demands that the whole population should be given equal opportunity to receive health care services when in need (Fiedler, 1984). Olsen (1997) differentiates between three theoretical objectives in achieving equity in health care resource allocation viz., utilitarianism which is based on the utility derived to enhance pleasure and decrease pain, egalitarianism where everybody gets equal share irrespective of need and the "maximin" objective which improves efficiency for the "worse-off". Resource allocation decisions in health care however need to be sensitive to the inherent inequalities and the impact on the different segments of the population (Wagstaff, 1994). This view is in support of those earlier held by Rushton (1988), who emphasises the need for models to be "demand-led" and participatory, addressing the stated goals and objectives of the stakeholders in the delivery system. This he argues will ensure greater equity and the adoption of the outcome of the model. Where rural and often resource poor livestock producers in extensive production systems are involved, the difficulty of attaining equity in resource allocation becomes even more pertinent.

When all socio-economic factors are accounted for, the availability of the service, which relates to the spatial distribution of the facilities vis-à-vis the population, emerges as the most important pre-requisite for utilisation and hence access to a facility or service. Access can be evaluated either through "process indicators" (factors which enhance or constrain utilisation) such as location or distance, or by the use of outcome indicators which characterise usage such as patient satisfaction or utilisation rates (Anderson and Aday, 1978). The decision to locate animal health facilities such that the whole population can receive the best possible access relates to the "central facility location problem" (Hodgart, 1978 and 1985). The problem deals with the distribution amongst a population of the benefits and indeed costs of sitting of facilities for optimality.

6.3 The theory of Location-Allocation (L-A) Models

6.3.1 The concept of Location-Allocation (L-A) modelling

The aim of location-allocation is to determine the best or optimal location for one or more facilities from which some service is to be provided to a spatially dispersed population (Goodchild and Noronha, 1983). The concept addresses two problems simultaneously:

1- The location problem, which relates to where to locate a facility given information on the distribution of a population.

2- The problem of allocation, which identifies which people should be served by what facility.

According to the nature of the utility derived, Hodgart (1978) classified facilities into three categories:

1- Central facilities. These are desirable user attracting facilities without objectionable characteristics. These include facilities such as schools, hospitals, fire stations etc.

2- Noxious facilities. These have undesirable characteristics and thus impose costs on the population. Facilities such as garbage incinerators fall into this group.

3- Hybrid facilities have both desirable and objectionable characters depending on usage. Abattoirs and discotheques may be considered in this category.[1]

Because of the utilities and dis-utilities associated with locating facilities, the decisions as to where such central facilities are located are perceived to be dependent on the bargaining power of the different social groupings of the society, with the affluent groups often benefiting more from location decisions.[2] The L-A models may thus be used to provide a means of ensuring more equitable allocation of resources by providing information on the distribution of the utilities and dis-utilities associated with the location of central facilities (Hodgart, 1978). Rushton (1988) thus proposed an equity related "service development theory" in facility location especially for rural areas of developing countries, as opposed to the "central place theory" on which earlier location decisions are based. He suggests that measures of access should be made separately for different social and economic groups. Optimality of spatial organisations and interventions must therefore be within the context of the socio-cultural, political and economic situations of each society.

6.3.2 Structure of Location-Allocation models

The precursors to models developed in solving location-allocation problems are attributable to the works by Kuhn and Kuenne (1962), Tornquist (1963), Tornquist et al (1967) and Cooper (1963 and 1967). These workers developed algorithms for

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[1] The siting of a discotheque is desirable for party-going populations, but the noise produced is a dis-utility for the neighbourhood, hence undesirable.

[2] Pinch (1985) argues that optimality depends on whose perception is sought. Wealthier pressure groups within society often have the sway in decisions relating to facility location.

allocating populations (demand) to facilities on a plane such that the aggregate travel distance travelled by the population is minimised. Other workers developed algorithms which solve the location-allocation problem but using existing road network (Maranzana, 1964, Teitz and Bart, 1968). The Euclidean (continuous space) models assume all points in a space are feasible locations and simply measure a straight line between the population and the nearest facility. On the other hand, network models which are considered more realistic assume that travel is limited to a network, often existing roads, and use the shortest path algorithms which find the shortest distance between one or more nodes in the network.

In general, any of the scenarios to be modelled can be represented by population weights w_i located at a series of points x_i, y_i and p facilities located at u_j and v_j. Of the w_i people, a number t_{ij} make use of the facility at location j thereby travelling distance d_{ij} in the process. In allocating demand to facilities, three assumptions are made (Goodchild and Noronha, 1983):

1- All population (demand) is allocated to a facility.

$$\sum_{j} t_{ij} = w_i \qquad (1)$$

2- Demand is allocated to nearest facility

$$t_{ij} = w_i \text{ if } d_{ij} < d_{ik},\ k \neq j \qquad \text{(k is location of another facility)} \qquad (2)$$
$$t_{ij} = 0 \text{ otherwise}$$

3- Allocation objective is a function of distance alone.

On the basis of the above assumptions, every individual within the population is allocated to the facility nearest to it without any consideration for the character of the population or the facility in question. Four objectives are recognised as informing the choice of models and hence solutions to location-allocation problems:

1- Minimise total (aggregate) distance travelled by population to facilities.

$$\text{Min} \sum_{i} \sum_{j} w_i\, x_{ij}\, d_{ij} \qquad (3)$$

2- Minimise maximum distance travelled by the farthest populations to facilities.

$$\text{Min Max}_{i,j}\ x_{ij}\ d_{ij} \quad (4)$$

3- Maximise population covered.

$$\text{Max} \sum_i \sum_j w_i\ x_{ij} \qquad \text{where } x_{ij} = 1 \text{ if } d_{ij} \leq s \quad (5)$$

$$\text{and } d_{ij} < d_{ik},\ k \neq j$$

$$\text{otherwise } x_{ij} = 0$$

4- Minimise total distance covered, subject to any specified distance, s constraint.

$$\text{Min} \sum_{ij} w_i\ x_{ij}\ d_{ij} \qquad \text{where xij dij} \leq s \quad (6)$$

The literature on network based modelling of location-allocation problems evolve around solutions aimed at three different problems, depending on the objectives as described above.

1- The P-Median Problem. The initial L-A models focused on the objective of minimising the aggregate travel distance for the whole population, and relates to the P-median problem as proposed by Hakimi (1964). He suggests that the *"location of p facilities on a network so that the average travel time of all users is minimum. Since the facilities are not distinguished by size or specialisation, it is assumed that every user will travel to his nearest facility"*. These models thus minimise travel distances for the whole population within the system. In this case the facilities are located such that the disparity in travel distance between all demand points (population units) in the whole system is minimised. This particular model ensures equity of access. However, a major defect of this approach is that the optima may result in some demand points (farther away) having excessive distances (time costs) from their nearest facility.

2- The Location Set Covering Models: The problem and solution to these set of models were first suggested by Toregas et al (1971). The models attempt to *"find the minimum number of facilities and their locations such that each point of demand has a facility within s time (distance) units"*. In other words, these models find the fewest number of facilities to cover the whole population and their locations. It thus takes care of the excessive distances attributable to P-median based models. The solutions however concentrate on minimising number of facilities while neglecting the population.

3- Maximal covering models. These models were first credited to Church and Revelle (1974). They *"allocate p facilities to positions on the network so that the maximum population will find services within a stated time or distance standard"*. These models maximise coverage as well as minimise number of facilities needed. In other words, they maximise attendance for the facilities, such that the facilities are located as close as possible to population densities there-by ensuring that attendance at each facility is maximised. Unlike the first case, here the disparity between the majority of the population and some other population units further away may be very large. This model guarantees maximum profit (usage) for the facilities, but not necessarily equity as it favours areas of high population density. It has the added advantage that it can indicate the maximum demand covered by a number of facilities less than the maximum required for total coverage (Revelle et al, 1977).

6.3.3 Description of algorithms

Several algorithms have been developed for the two geometric approaches to solving the location allocation problems. The main difference between the network and the Euclidean space algorithms is that the number of searches in the network models can be greatly reduced by confining these to the nodes on the arcs (Hakimi's theorem), as opposed to the infinite number of feasible locations in a Euclidean search. The Cooper and Kuhn-Kuenne algorithms constitute the most basic of the techniques that utilise the Euclidean space. A simplified version of the algorithms would involve the following steps:

1- Select starting locations for facilities.

2- Assign each member of population to nearest facility. This step creates a set of catchment areas (Thiessen polygons) for each facility.

3- Move facility in each catchment area to a new location with the minimum aggregate travel distance.

4- Re-assign each population to nearest facility using new locations.

5- Repeat above two steps until convergence occurs (Minimum aggregate travel distance for whole population).

For the network geometry, the Maranzana Algorithm is probably the earliest and most basic and involves the following steps (Hillsman, 1980):

1- Select starting points.

2- Assign each node to its nearest facility.

3- For each facility;

a- Identify the nodes in its service area.

b- Compute aggregate distance from the nodes in 3a to each candidate node in the catchment area.

c- Move the centre to the candidate for which the aggregate distance in 3b is smallest.

4- If no centres were moved in step 3, stop, otherwise return to step 2.

Earlier models have been limited to discrete catchment areas and based on inelastic demand. In real life however, in addition to tapering effect (distance decay), service usage (demand) is known to be spatially elastic and hence sensitive to distance (Hodgart, 1985). L-A models developed in recent years tend to be hybrid in nature and have capabilities both to search in Euclidean space or along road networks. Furthermore, spatial interaction models with multi-objective capabilities and the ability to evaluate demand with overlapping catchment areas have been built. The problem of elasticity of demand was addressed in one instance, by assuming that services with elastic demand decline in a negative exponential way, and thus represented by the following equation (Hodgart, 1985):

$$T_{ij} = p_i e^{-bd_{ij}} \quad (7)$$

where T_{ij} is the number of visits from i to facility j during a particular period of time; and *b* defines the degree of elasticity.

Hodgart (1981) resolved the problem of overlapping catchment areas by first determining the total attraction TA exerted on a demand point i by all the facilities;

$$TA = \sum_{j=i}^{m} e^{-bd_{ij}} \quad (8)$$

where b is a "trip dispersion" parameter which determines the extent of the catchment areas.

and then computing the fraction of the demand from i going to a particular facility;

$$F_{ij} = {e - bd_{ij}} \Big/ {\sum j e^{-bd_{ij}}} \quad (9)$$

The spatial interaction objective which includes the ability to handle overlapping catchment areas as well as elasticity of demand was captured by Hodgart (1981) in his L-A model LOCHWISP (Location of Centres Heuristic With Iterative Search on a Plane). LOCHWISP has two objectives; one of maximising usage and the other to maximise net balance of specified costs and benefits. Although, it only has the capacity to search and optimise one objective at a time, it does provide statistics of the levels of other objectives as output. Hence, the output of the other objective which is to maximise other net benefits for different modelled scenarios could either be considered alongside the maximisation output or specifically modelled for, since the objective exists in the model as an alternative algorithm.

The problem of overlapping catchment is handled in Hodgart's model by allocating demand points to centres on the basis of their relative attractiveness as computed by the equation (9) above. Meanwhile, incorporating equation (8) above into the algorithm permits the evaluation of the effect of elasticity of demand. Hodgart's model involving an alternating type of algorithm which uses a simple spatial interaction model to define overlapping catchment appears more appropriate in addressing real life location-allocation problems than models which use simple Thiessen catchment (Hodgart, 1981).[3]

GRAFLOC, the model used for this study was based on LOCHWISP but has the added advantage of a graphical display output (Finnegan, 1994). GRAFLOC

[3] Thiessen Polygons describe the catchment areas of facilities in which there is no overlap.

addresses the objective of minimising aggregate distance travelled for all, and hence travel costs, there-by ensuring equity of access for the whole population. The allocation of population units to facilities pre-supposes that each demand centre is allocated to its nearest supply centre (facility) using Euclidean space, a network capability also exists GRAFLOC. Four output files are generated by GRAFLOC (See Appendix 1 for sample output files and GRAFLOC Monogram):

1- The Spider-graph is a graphical representation of the location-allocation results of the enquiry. All supply points (facilities) are represented by points on a Northing-Easting graph which represent their latitude-longitude co-ordinates. Demand points (population centres) allocated to each supply point (animal health facility) are presented as lines linking the co-ordinates representing the location of the populations centres (demand points) and the locations of the animal health facilities (supply points).

2- The Costs Output File generates a table of mean and maximum travel distances (costs) for each of the facilities. A figure for the total aggregate travel cost for the whole population is also generated. This is based on the travel distances (costs) of each of the demand units (population) allocated to each supply point (facility), and represents the distance travelled by each member of the population, when they make a single journey to their nearest facility. The unit of travel cost is in kilometres, but can be converted into time or monetary units.

3- The Profile Output File gives the percentage proportion of the total population, allocated to each facility within any specified distance ring. Similar figures for the whole system are also included at the end of the table.

4- The Statistics Output File provides information on each facility and for each specified distance ring, the percentage proportion of the total population allocated, the cumulative percentage proportion, the number of demand units allocated and the aggregate travel distance (cost). The maximum and the mean travel costs as well as the latitude-longitude co-ordinates for each facility is also provided, and at the end of the table, the maximum and the mean travel costs for the whole system is provided.

The modelling exercise undertaken in this study allocates demand points for services to their nearest facilities thereby minimising travel costs. The results are then displayed in tables of aggregate distances and mean travel distances, population within distance rings as well as notional catchment areas. In essence, the models relate locations with uptake, and through the comparison of Mean Travel Distances (MTDs) for different scenarios of different facilities in the system, equity of access of the population can be compared and inferred. Furthermore, when the population figures of notional catchment areas are "weighted" for expenditure or income, it is possible to compare the income generating potentials for different facilities in different locations and hence their viability.

6.3.4 Limitations of the model

The major limitation of the current technique is that it does not reflect the quality of the services provided by each facility, neither is it sensitive to the capacities of the facilities. Thus the model allocates demand to facilities irrespective of any specialisation that might exist within individual facility. However, a knowledge of the study area situations will help correct such errors. Although network capabilities exist with this model, the use of Euclidean space simplifies and speeds up analysis hence the choice of Euclidean geometry. It is recognised however, that this would neglect any possible effect of natural barriers such as mountains or lakes. In Zimbabwe, the effects of topographic barriers are minimal when considering the movement of the national herd, especially in communal areas where livestock movement is often Euclidean across fields and seldom along road networks.[4]

6.4 Methodology

6.4.1 Data Sources, Types and Characteristics

Different data-sets were required for the various scenarios modelled for the two categories of production systems or demand types in Zimbabwe. Demand for small animal practice in urban Harare, was modelled using the human population census

[4] Where short distances are involved, the difference between network and euclidean analysis is minimal.

dataset of the households in 101 enumeration centres representing the different suburbs of Harare. Ranking of the suburbs of Harare on levels of income of the households was done to provide datasets for three additional scenarios. The technique used in the ranking exercise involved finding an index of household wealth for each suburb, by taking three, 500 random samples of entries in the telephone directory for Harare and registering the suburb. The average number of entries per suburb is compared to the number of households in the suburb. This assumes that telephone ownership is indicative of wealth and the average number of telephones (per household) in a suburb provides an index of wealth of the suburb. The result of this indexing exercise was corroborated by circulating a list of all the suburbs of Harare to five residents who were required to rank these according to wealth based on their knowledge of the city. On the basis of this ranking exercise of the various suburbs, the 295 thousand households in Harare were categorised as belonging to the following income groups; 49 thousand high income, 40 thousand middle income and 206 thousand low income households. [5]

The demand for large animal services in Zimbabwe was modelled using the diptank census datasets of the 3.4 million communal cattle and the Intensive Conservation Areas (ICA) datasets of the 1.6 million commercial cattle, coming from 2306 and 160 enumeration centres respectively.[6] These collectively form the Zimbabwean national herd of cattle. Further scenarios were modelled to reflect current policy issues under discussion in the country and these include, veterinary expenditure and attractiveness for private practice weightings, computed from the surveys conducted for the different production systems of Zimbabwe. The locations of the eleven veterinary practices in Harare were digitised during the survey, and the co-ordinates used as the supply points for urban small animal practice scenarios, while sixty three

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[5] Wealth ranking of households in different surbubs of Harare provided a means of categorising the surburbs into high, medium and low income surburbs. This is achieved by simply ranking the 101 suburbs on the basis of their wealth index (Telephone ownership per household), and splitting them roughly into three parts.

[6] In Zimbabwe, census for communal cattle is conducted at diptanks usually located not farther than 5 kilometres from the herds. Commercial cattle census is conducted at intensive Conservation Areas (ICA).

locations country-wide identified during the survey as containing one or more facilities with a veterinarian (private or government), were used as supply points for the large animal practices scenarios. In every case, the longitude and latitude co-ordinates of all the demand and supply points were computed and used in the model, as well as the population figures associated with each demand point. A number of scenarios modelled, especially on viability and sustainability of the systems, made use of data derived from descriptive summaries of statistical analysis from the results of the questionnaires and other sampling techniques undertaken during the study. These include information on the socio-demography, veterinary expenditure or income, and the animal health-care utilisation by the various users and providers within the delivery system, as well as a wealth ranking exercise for the suburbs of Harare.

6.4.2 Modelling framework

The framework for testing the three null hypothesis in this study involves modelling different policy scenarios involving facility location and evaluating the output for efficiency, equity and viability or any other set policy objective. This involves the following format:

1- Modelling the status quo.

2- Modelling an alternative scenario.

3- Comparing output of alternative scenario and the status quo for efficiency and equity of access.

4- Extrapolating socio-economic and other demographic data from field survey nationally using population figures, model output data and decision analysis.

Output data from the modelling exercise permits the evaluation of two dimensions of demand (population under study), viz., the population numbers allocated to the various facilities and the travel costs (distances) incurred by the population using those facilities. A total of six scenarios of animal health facility allocations in Zimbabwe will be evaluated using the L-A models. Four of these involve small animal practices in Harare and the other two involve the distribution of facilities for providing services to the National herd of cattle.

1- Scenario 1. Existing (status quo) veterinary clinics in Harare. This represents the allocation of the population of Harare households to the eleven existing practices, the assumption being that there is a correlation between household numbers and pet populations.

2- Scenario 2. Relocation of all existing clinics in Harare. Here, the clinics were allowed to relocate by the model to their optimum location.

3- Scenario 3. Closure of two Harare clinics (PVO and Borrowdale). The model re-allocates the household populations to nine of the original ten clinics, based on the closure of Borrowdale and the Principal Veterinary Office (PVO) clinics. This is on the understanding that these two clinics are specialised facilities, equine practice and government regulatory services respectively, and therefore should not be included for small animal practice analysis.

4- Scenario 4. Opening of two additional clinics (near Greencroft and Chisipite). Based on the results of the initial set of analysis, it is suggested here that, two practices be opened, one near Society for the Prevention of Cruelty to Animals (SPCA) clinic and the other near Greencroft clinic, as they are shown to have rather high Mean Travel Distances (MTDs) which implies that their clients have to travel the farthest.

5- Scenario 5. Modelling existing facilities for National herd of cattle (status quo). This evaluates the demand dynamics involving existing veterinary clinical facilities.

6- Scenario 6. Relocation alternatives for facilities for the national herd of cattle is explored in this scenario.

6.5 Results and discussion

6.5.1 Catchment populations of Harare Small Animal Practices.

Table 6.1 and Table 6.2 provide a breakdown of the population of Harare households allocated to each facility under the four scenarios of small animal practice modelled. In Table 6.1, the absolute population allocated and the proportion of total are compared, while Table 6.2 permits a comparison of the proportions of the households belonging to various income levels allocated to each clinic under the four scenarios modelled. In Table 6.1, Scenario 1 (status quo) suggests that about 90 percent of Harare households would be served by just five of the eleven existing clinics, with the SPCA clinic serving over 40 percent of the population (See Figure 6.1). Meanwhile, the remaining six clinics would only serve 10 percent of the population. However, if all the clinics were allowed to relocate, referenced to their original locations (Table 6.1, Scenario 2), a more even spread of catchment is achieved, with those earlier depleted six clinics increasing their share of the market to about 36 percent from the initial modest 10 percent (See Figure 6.2).

Figure 6.1. Proportion of Harare households allocated to veterinary clinics in existing locations

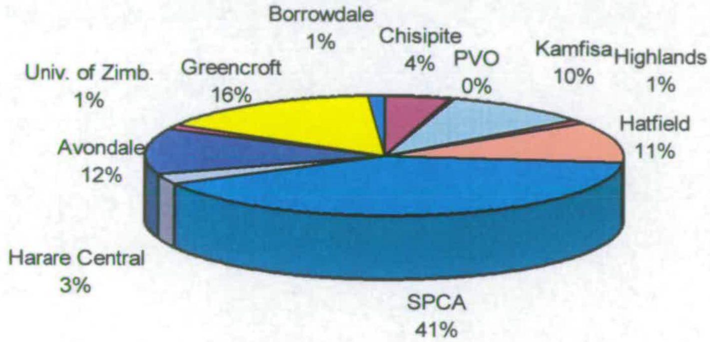
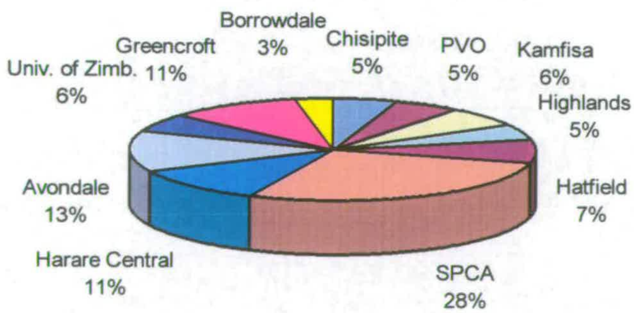


Figure 6.2. Allocation of Harare households to veterinary clinics relocated to more optimum locations



Closing two specialist clinics, PVO and Borrowdale (Table 6.1, Scenario 3) did not result in any significant difference in the share of the market for most of the clinics, with only Avondale, University of Zimbabwe and Highland clinics benefiting marginally. On the other hand, if those same clinics (PVO and Borrowdale) remain closed, but two new clinics were allowed to open referenced to SPCA and Greencroft clinics, there is a major drop in the share of the original SPCA and Greencroft clinics, as well as the market share of Avondale clinic (Table 6.1, Scenario 4). These clinics are seen to lose their clients to the new additional clinics (Add-SPCA and Add-Greencroft), suggesting that these new clinic locations are superior or better located (more efficient) than their parent clinics.

Table 6.1
Proportion Of Harare Households Allocated to the Veterinary Clinics Under the Four Scenarios Modelled.

Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Clinics	% of Total Popn	% of Total Popn	% of Total Popn	% of Total Popn
Chisipite	4.33	4.97	4.33	4.33
PVO	0.38	5.30	N/A	N/A
Kamfisa	9.69	6.09	9.69	9.69
Hatfield	10.80	7.40	10.80	10.80
SPCA	40.49	27.65	40.49	9.42
Harare Central	2.76	11.35	2.76	2.76
Avondale	12.48	12.71	12.86	2.88
Greencroft	15.60	10.53	15.60	5.58
Univ. of Zimb.	1.12	5.83	1.41	1.41
Borrowdale	1.10	3.05	N/A	N/A
Highlands	1.24	5.12	2.06	2.06
Add-SPCA	N/A	N/A	N/A	34.08
Add-Greencroft	N/A	N/A	N/A	16.99

N/A Not Applicable

The relocation of all the clinics around existing practices as well as the closure of the two specialist clinics did not significantly change what segments of the population each clinic is serving (Table 6.2). However, the two clinics opened in scenario 3, took over about 50 percent of low income householders, 38 percent of middle income householders and 11 percent of high income householders. Significantly, the new SPCA clinic (Add-SPCA) emerged as being strategically located for serving lower income householders by catering for about half of the total population of low income households in Harare. In addition to the changes in the proportion of the households allocated to each clinic in the various scenarios (Tables 6.1 and 6.2), the comparison of the various Mean Travel Distances (MTDs) is particularly important, as it provides a quantitative means of evaluating access (Table 6.3).

Table 6.3 shows that the average distance travelled by Harare households to their nearest clinic is just over 7 kilometres per visit, and this distance changes very little even when the PVO and Borrowdale clinics are closed down. However, the MTD for the whole system decreases by over 3 kilometres if new clinics are opened near SPCA and Greencroft (Scenario 4), an improvement in access of about 42 percent. Probably even more significant however, is the analysis of the distances travelled by the households in the different suburbs belonging to various income groups under different clinic location scenarios. Table 6.1 shows that closure of the specialist clinics (Scenario 3) had a slight impact on households living in high income suburbs, but no impact whatsoever on households in low and medium income suburbs.

Table 6.2
Proportion of Harare Households Belonging to Different Income Groups Allocated to Veterinary Clinics.

	Scenario 1			Scenario 2			Scenario 3			Scenario 4		
Clinic	Hi	Med	Low	Hi	Med	Low	Hi	Med	Low	Hi	Med	Low
Chisipite	21.94	0	1.02	18.02	0	1.02	21.94	0	1.02	16.16	0	1.02
PVO	2.28	0	0	6.85	0	0	N/A	N/A	N/A	N/A	N/A	N/A
Kamfisa	2.49	23.56	8.70	4.99	23.56	8.70	2.49	23.56	8.70	2.49	23.56	8.70
Hatfield	0	21.33	8.38	12.45	21.33	8.38	12.45	21.33	8.38	12.45	21.33	8.38
SPCA	0	23.65	53.31	0	23.65	30.36	0	23.65	53.31	0	6.26	11.86
Harare Central	16.70	0	0	13.93	0	0	16.71	0	0	16.71	0	0
Avondale	15.17	0	14.26	11.10	0	31.45	17.46	0	14.26	17.46	0	5.76
Greencroft	7.97	31.47	14.44	8.55	31.47	20.09	7.97	31.47	14.33	6.27	11.18	14.33
Univ. of Zimb.	6.81	0	0	12.43	0	0	8.51	0	0	5.11	0	0
Borrowdale	6.69	0	0	6.69	0	0	N/A	N/A	N/A	N/A	N/A	N/A
Highlands	7.48	0	0	4.99	0	0	12.47	0	0	12.47	0	0
Add-SPCA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	17.38	49.95
Add-Greencroft	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10.89	20.29	0

Table 6.3
Comparative Analysis of MTDs of Different Scenarios of Small Animal Practice Locations in Harare.

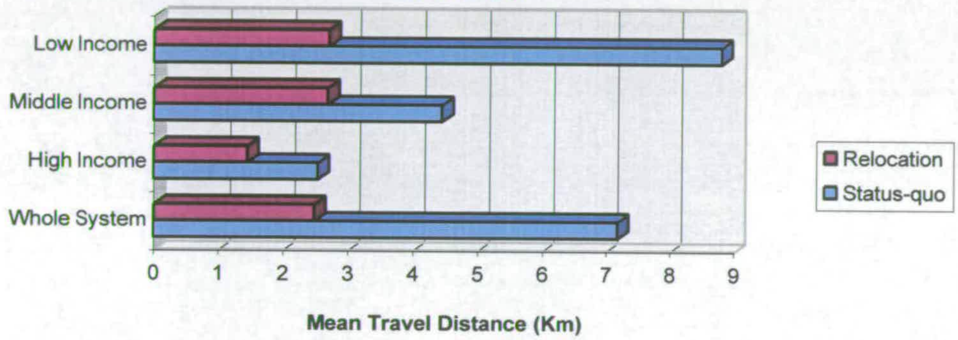
Scenarios	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
Client Type	MTD	% Improve	MTD	% Improve	MTD	% Improve	MTD	% Improve
Whole System	7.17	N/A	2.48	65.40	7.18	-0.14	4.13	42.40
High Income	2.53	N/A	1.44	43.10	2.64	-1.53	2.37	2.23
Middle Income	4.44	N/A	2.68	39.60	4.44	0	3.09	18.82
Low Income	8.79	N/A	2.70	69.30	8.79	0	5.46	37.88

MTD = Mean Travel Distance.

N/A Not Applicable

On the other hand, opening of two clinics near the two busiest clinics, SPCA and Greencroft clinics resulted in very significant improvement in access over the original locations, 38 and 19 percent improvement, for households living in low and middle income suburbs respectively (Scenario 4). When all the clinics were allowed to re-locate to more optimal locations, a general and significant improvement was achieved right across all income groups (Scenario 2), clearly suggesting sub-optimality of access for the present locations (See Figure 6.3). A case is thus made for relocating some of these clinics.

Figure 6.3. Distances travelled to veterinary clinics by different Harare households under different clinic location scenarios



6.5.2 Notional Catchment for Cattle Facilities in Zimbabwe

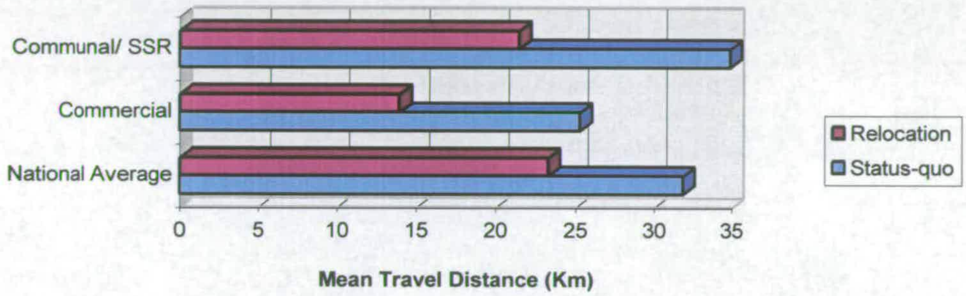
Sixty three towns are identified as having facilities potentially manned by veterinarians for providing clinical services. Scenario 5 provides the allocation of the national herd of cattle (communal and commercial) to these locations. Scenario 6 compares the allocation of commercial and communal cattle to the 63 facilities after all the facilities were allowed to freely relocate to more optimum locations by the model. Because of the large number of clinics involved, a case by case examination of the catchment of each clinic will not be undertaken in this discussion.[7]

Table 6.4 provides a comparative analysis of the MTDs for the two scenarios (Scenarios 5 and 6) modelled for the large animal facility locations (see Figure 6.4). The result of the modelling exercise shows that, while the average national herd is about 32 kilometres from the nearest clinical facility, the livestock on commercial

[7] Figure 6.5 shows the disparity between the existing locations and the relocation alternatives, the co-ordinates of the two are displayed using GIS Arc-Info, and the administrative district boundaries overlaid.

farms are only about 25 kilometres from their nearest clinic, but the communal and small scale livestock are 10 kilometres farther at 35 kilometres (See Figure 6.4). On the other hand, the MTD for the national herd falls from 32 kilometres to 23 kilometres if the relocation scenario (Scenario 6) is instituted, an efficiency savings of about 9 kilometres per head per visit or 45 million kilometres per visit for the national herd of about 5 million cattle.

Figure 6.4. Mean Travel Distances (MTD) to veterinary clinics by different livestock producers under different scenarios of clinic location



It is worth noting that, although the overall MTD for all categories of producers fall following relocation, the maximum travel distance actually increases for those farms farther away (Scenario 6). As discussed earlier, such is the likely consequence of adopting the objective of minimising MTDs for the whole population.

Table 6.4
Comparative analysis of MTDs between Status quo and All Clinic Relocation Alternative for Clinical Facilities Serving Zimbabwe's National Herd of Livestock (Cattle).

Production System	Scenario 5		Scenario 6		Savings on Mean TD		
	Mean TD	Max TD	Mean TD	Max TD	(KM)	(%)	Mill Zimb $
National	31.83	119.30	23.26	111.7	8.57	26.90	65.47
Commercial	25.26	66.70	13.93	73.70	11.33	44.90	1.45
Communal/ SSR	34.87	119.3	21.42	134.4	13.45	38.60	64.02

6.5.3 Travel cost savings

The techniques described above have potential applications in improving the delivery of agricultural services especially to poor and rural communities that are likely to be further marginalised by policies promoting market economies and privatisation. Such policies tend to neglect issues of equity of access, which quite often are not so obvious to planners especially in the absence of tools and techniques such as this, which can assist in quantitatively determining the inherent inequities likely to be created by the policies.

There are 1.6 million heads of commercial and 3.4 million non-commercial cattle in Zimbabwe. Results of the survey conducted in the country shows that, the average number of visits to or from the veterinary clinic for both production systems is between 6 to 6.5 visits per year (Chapter 4, Table 4.1b). Meanwhile, the average herd size for commercial producers is 344.2 heads of cattle, or 0.02 visits per head, and 19.9 heads per non-commercial (communal) herd or 0.35 visits per head. The average travel cost in Zimbabwe (during the survey) was Z$4 per kilometre. When these figures are used in conjunction with the mean travel distance (cost) savings as predicted in scenarios five and six above, the real financial savings to the rural communal farmers in Zimbabwe can be computed (Table 6.4). i.e.:

Financial Savings = MTD Savings x VetVisit/ head x Total Population x Z$4

Currently, the location of most government veterinary facilities is based on existing political administrative structures, with the clinics and veterinarians residing in the district headquarters. The efficiency of such location decision is not very important especially as the government is responsible for travel costs for providing clinical services to farmers. With privatisation however, farmers will be expected to bear the full cost of the services they receive, including the travel costs. Thus the location of the facilities in relation to the different producer groups becomes very important. Immediately apparent with this analysis is the significant efficiency savings in annual travel costs to Zimbabwean farmers especially those in communal (rural) farming systems (Z$ 64 Million), following the relocation of existing veterinary infrastructure to more optimal locations. Since travel cost between clinics and farms are recurrent and will be incurred annually by the farmers for as long as the facilities and the farms remain in their current locations, it becomes obvious that over time, say ten years, savings to farmers from a relocation exercise would be significant (Z$ 650 Million), and is likely to defray any costs arising as a result of the relocation exercise itself, especially as this is likely to be a one off cost. The above analysis brings into question therefore, the rationale of having the existing facilities in their current locations. Not only does it favour the commercial farmers, but the system as a whole is sub-optimal, as 9 kilometres or an appropriate equivalent in travel costs (units of time and /or money) is lost on the average, every time a member of the population travels to a clinic or is visited by the veterinarian, as the case is likely to be.

6.5.4 Viability considerations

As was discussed in the conceptual framework (Chapter 3), for a facility or location to be considered viable, it must have a Practice Viability Index (PVI) equal to or greater than 1. This involves subjecting the net practice income of the facility to a decision analysis involving a computed Veterinary Coefficient (VC) for the country (Odeyemi, 1993). The VC calculated for Zimbabwe private practices currently stands at Z$ 1,015,333, and represents the amount that the practice must be able to generate in a year from fees charged and drug sales from the proportion of animals that are likely to be treated within its practice area. The average practice area of veterinary practitioners surveyed in Zimbabwe currently stands at about 35 kilometres radius of the facility (ZVA Survey 1995). The VC is the sum of the current average income per annum of a private practitioner in Zimbabwe (Z$ 122,000), the current average running costs of a practice per veterinarian per chargeable working hours in the year (Z$200 x 8.7 hrs/day x 280 days/year), and the proportion of gross earnings contributed by drug sales, estimated at 40% of gross for Large animal practice (ZVA Survey 1995). i.e.:

Viability Coeff. = Vet Salary + Avg. Running Costs + Avg. Drug/Input Sales

Figure 6.6 displays the PVIs or viabilities computed for the existing 63 locations or clinical facilities in Zimbabwe. This was derived by allocating the Zimbabwean national herd of cattle to the 63 facilities using the L-A model, and determining individual notional catchment for each practice area (35 km radius).[8]

[8] Veterinary expenditure used is weighted for the two production types.

Figure 6.5 Displacements following optimum relocation of clinics in Zimbabwe

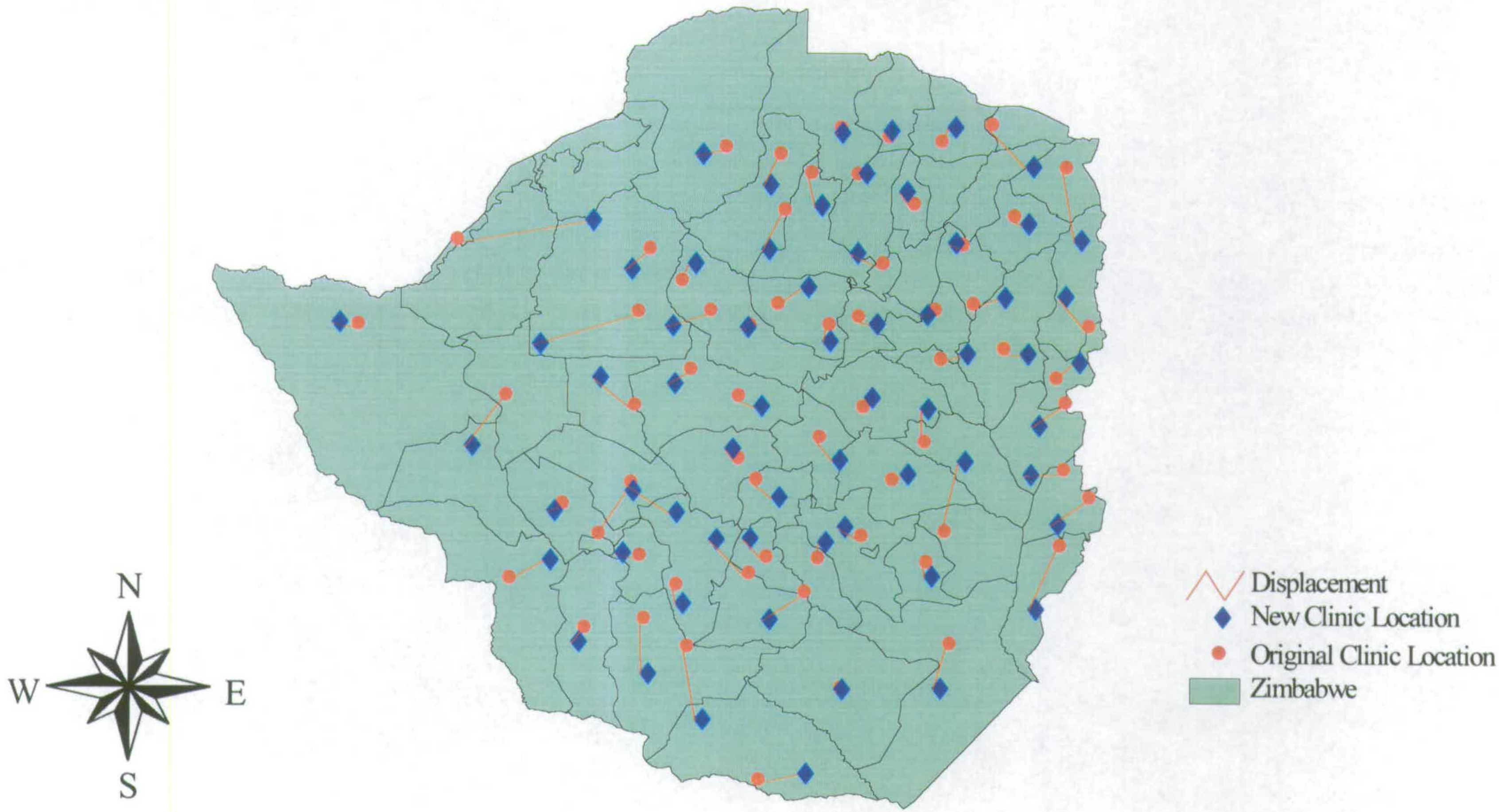
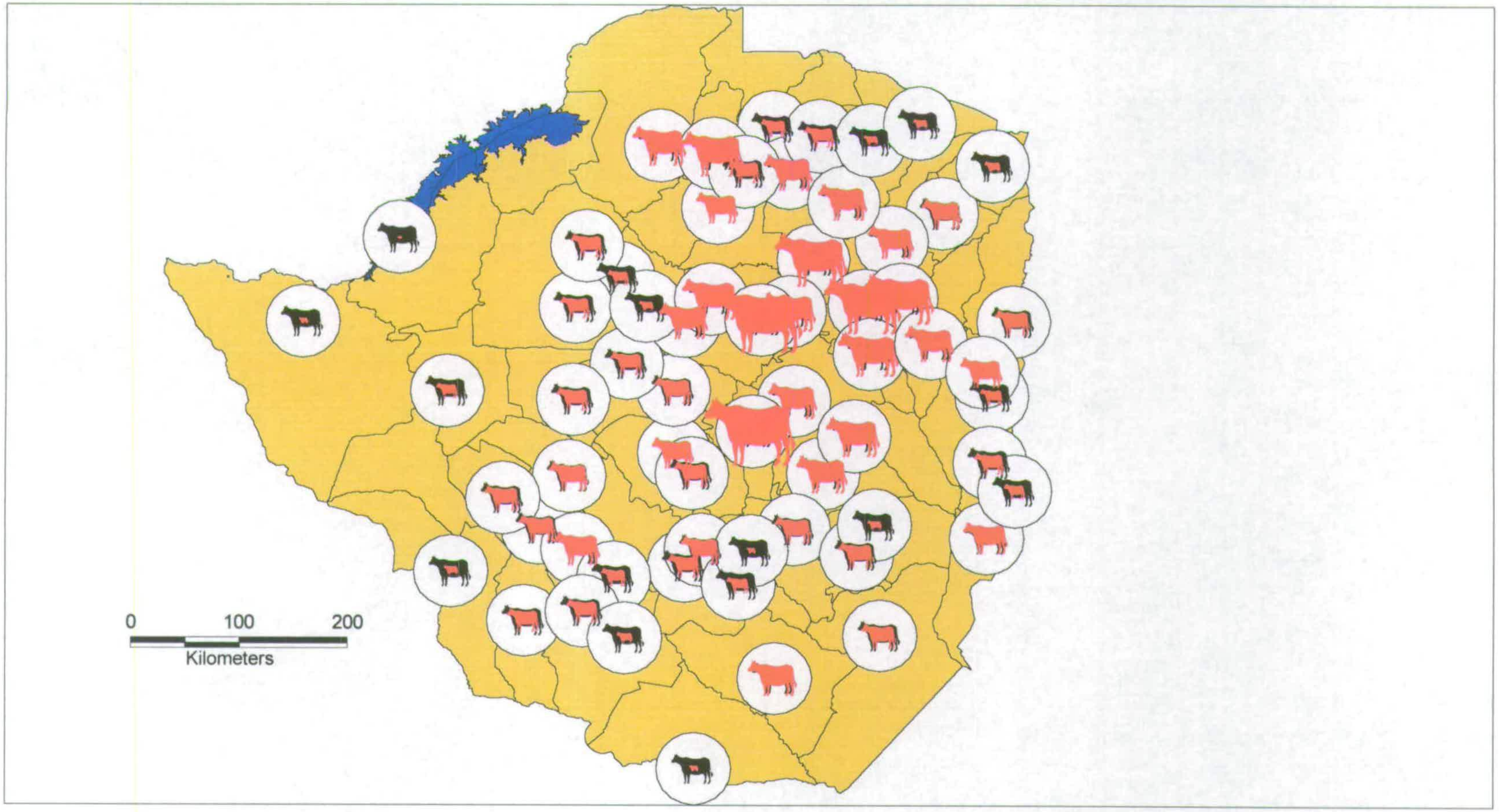


Figure 6.6 Relative Viability of Veterinary Facilities for Cattle in Zimbabwe



N.B.

- Locations with Black Cows represent non viable facilities (i.e. PVI<1)
- Red Cows depict clinical facilities with viabilities ranging from 0.2 to 6 PVI

Each notional catchment population is then subjected to a decision analysis involving the Veterinary Coefficient calculated for Zimbabwean private practices as above. The current exercise suggests that the 63 locations can sustain nearly 84 farm animal practices between them, with the viability ranging from 0 to 5.7 (Table 6.5).

Table 6.5
Practice Viability Indices (PVIs) for Farm Animal (Cattle) Clinical Facilities in Zimbabwe.

LOCATION	MTD	PVI	COMMERCE. CATTLE (%)	COMMUN. CATTLE (%)
System	31.8	83.9	68.5	31.5
MVUMA	21.4	5.7	32.7	67.3
MUBAIRA	25.8	5.5	94.4	5.6
MARONDERA	25.1	4.4	87.9	12.1
HARARE	30.8	3.9	99.3	0.7
MACHEKE	27.7	3.7	92.5	7.5
MHANGURA	26.0	2.8	91.1	8.9
WEDZA	25.5	2.8	52.3	47.7
CHEGUTU	30.0	2.5	91.0	9.0
KAROYI	36.2	2.2	86.0	14.0
BEATRICE	24.3	2.2	82.8	17.2
BUHERA	33.0	2.2	100.0	0.0
GUTU	23.9	2.1	95.5	4.5
MVURWI	17.9	2.0	93.7	6.3
MWENEZI	40.7	2.0	100.0	0.0
BINDURA	26.5	2.0	83.7	16.3
RUSAPE	29.9	1.9	97.8	2.2
CHIVHU	27.0	1.9	66.4	33.6
KADOMA	19.6	1.9	89.3	10.7
MUREWA	21.8	1.8	89.0	11.0
ESIGODINI	20.1	1.8	50.6	49.4
CHIPINGE	38.8	1.6	97.4	2.6
MUTASA	23.6	1.5	100.0	0.0
CHINHOYI	35.4	1.5	60.9	39.1
GWERU	25.0	1.5	57.2	42.8
INYATHI	33.9	1.3	18.7	81.3
ZVISHAVANE	26.7	1.3	56.2	43.8
MUTOKO	33.5	1.3	57.6	42.4
KWEKWE	23.8	1.2	82.9	17.1
BULAWAYO	20.1	1.2	100.0	0.0
MASVINGO	28.4	1.2	59.1	40.9
SHURUGWI	31.1	1.1	99.3	0.7
NYAMANDHLOVU	28.1	1.1	42.0	58.0
ZAKA	24.6	1.1	3.0	97.0
NYANGA	38.8	1.1	100.0	0.0
CHIREDZI	45.6	1.1	93.0	7.0
MBERENGWA	38.6	1.0	94.9	5.1
RAFFINGORA	15.8	1.0	0.0	100.0
NKAYI	36.9	1.0	0.0	100.0
NEMBUDZIYA	27.0	0.9	66.3	33.7
ZHOMBE	20.2	0.9	100.0	0.0
GWANDA	28.8	0.9	80.2	19.8
KEZI	36.3	0.9	73.4	26.6
GOKWE	40.1	0.8	88.0	12.0
NEDZIWA	37.8	0.8	0.0	100.0
CENTENARY	14.3	0.8	91.8	8.2
GURUVE	16.6	0.6	0.0	100.0
FILABUSI	19.3	0.6	0.0	100.0
MUTARE	35.0	0.5	0.0	100.0
BUEHWA	28.0	0.5	0.0	100.0
SANYATI	28.7	0.4	0.0	100.0
LUPANE	58.5	0.4	0.0	100.0
CHIMANIMANI	19.6	0.4	3.5	96.5
WEST NICHOLSON	50.1	0.3	0.0	100.0
MUDZI	38.8	0.3	0.0	100.0
LAZY Y RANCH	28.6	0.2	0.0	100.0
MOUNT DARWIN	16.8	0.2	48.9	51.1
BIKITA	37.9	0.2	0.0	100.0
RUSHINGA	26.9	0.2	0.0	100.0
PLUMTREE	45.2	0.2	0.0	100.0
BEITBRIDGE	48.7	0.1	0.0	100.0
CHIVI	18.0	0.1	0.0	100.0
HWANGE	51.7	0.1	0.0	100.0
BINGA	73.6	0.0	0.0	0.0

Only 38 of the 63 locations can generate sufficient income to be financially self-sustaining (i.e. viable), while 25 are non-viable.[9] Table 6.5 permits a comparison of the PVIs for the various locations, the MTD of the population allocated to each facility, as well as the proportion (in percent) of the different farming systems contributing to the income generated by the facility.

It is therefore possible to take decisions on equity of access of the various facilities, as well as attractiveness for private practice of each facility, viability not withstanding. For instance, a facility that is clearly non-viable (low PVI) and also is less accessible (high MTD) is a clear candidate for down-grading to be replaced by one or more Animal Health Management Centres (AHMCs), which are less expensive to manage and can be located to enhance access. On the other hand, if the facility is only marginally non-viable, but is very accessible to a high population (low MTD), such a facility may be subsidised to maintain a practice. A cursory look at Table 6.5 clearly shows that most facilities or locations that emerged to be viable (PVI>1) at 35 kilometre practice area predominantly serve commercial cattle. Meanwhile, those facilities that serve predominantly non-commercial cattle emerged to be non-viable (PVI<1). This would appear to support the hypothesis that viability of private veterinary practices is dependent on the presence of commercial farms. Hence, one can deduce that, the proportion of income contributed by commercial and communal cattle to a facility is an indication of how attractive the facility is likely to be for private practice, and may thus be a major consideration in determining what model of practice to put in place It is recognised that, the dynamics of providing a service in a practice supported exclusively by either of the above production systems will be different. Thus the proportion of either production system supporting a practice will be important where decisions regarding marginal viability is concerned, especially in terms of whether a practice should be subsidised or down-graded to paravet facility status. For instance, it is expected that, locations with PVI

[9] The cost of travel to provide services is considered in this analysis as government currently pays the transportation bills of clinicians providing services to livestock producers. The PVI values may thus only be a rough guide to the actual viabilities.

greater than 1, especially from about 1.5 to 2 upwards would quite easily sustain a practice, where as locations with PVIs lower than 1, and in particular 0.5 or less would probably need to be down-graded or shut completely. However, where these represent politically or economically sensitive locations such as provincial capitals, location of high human population, border posts or important wild-life parks, a political decision to subsidise may be considered, so as to retain a practice there.

The analysis of the current veterinary personnel dynamics in the Directorate of Veterinary Services of Zimbabwe suggests that the existing 63 veterinary clinical facilities (or locations) are managed by 54 veterinarians and nearly 3,000 support staff, an average of about 45 personnel per clinic, excluding another 2500 personnel in administration, research, training and meat inspection (DVS Field Report, 1995). On the other hand, the average private practice in Zimbabwe comprise of 2 clinicians and 5 support staff (ZVA Survey, 1995). It is clear from the above that, subsidising a private practice to manage a non-viable or marginally viable but unattractive practice location, is likely to be more cost effective than maintaining a government presence in the locations at the current manning levels.

6.5.5 Financial sustainability versus equity

When evaluating animal health care policies in any country, it is usually necessary to be able to visualise and quantify where possible, the socio-economic consequences on the population, of the different policy options being considered. For instance, in the case of a policy to privatise clinical services to livestock producers in Zimbabwe, the major consideration is often the knowledge of which of the existing veterinary facilities that are likely to be financially self-sustaining under different policy scenarios. However, while the location of these facilities and the proportion of the national herd covered is important, it is probably more useful in some cases to know how the different types of livestock producer groups will be served. In other words, one needs to determine the proportion of the different production systems covered, whether from commercial or non-commercial (communal and rural) herds. It is only when such information is available, that it is then possible to determine the social-cost benefit considerations of the policy, with regards to the different socio-economic groupings in the population. This may then inform the type and level of government participation required.

The current model allows resolution of some of the problems above in a more appropriate manner than would have been possible before now. Table 6.6 presents the summary of the result of the modelling of 4 different scenarios of the national herd of cattle in Zimbabwe. The table compares the number of fully self financed veterinary facilities and locations in Zimbabwe under four different scenarios of practice areas to be covered by existing veterinary facilities.

Table 6.6
Coverage of Self-Financing Veterinary Facilities in Zimbabwe
Under Different Range of Practice Area.

Distance from Clinics	Number of Self-Financing Locations	Private Practice Equivalent	Proportion of National Herd Covered (%)	Proportion of Commercial Cattle Covered (%)	Proportion of Non-Commercial Cattle Covered (%)
25 km Radius	20	34	19.11	38.91	9.99
35 km Radius	38	78	46.78	70.82	35.67
45 km Radius	39	91	65.02	86.47	55.09
Full Coverage	45	112	88.77	96.58	84.48

Three distances were selected, 25 kilometres, 35 kilometres and 45 kilometres, which represent the minimum, mean and maximum distance ranges as indicated in the provider survey conducted, as well as a possible 100 percent coverage for purposes of comparison. Once again, this analysis assumes that no additional travel cost is incurred in providing services for the different range of distances. Column 2 of Table 6.6 presents the number of existing 63 locations that will be financially self sustaining, while data in column 3 represent the actual number of practices sustained based on the costs of running the average Zimbabwean private practice. Columns 4-6 present the proportions of the national herd, commercial cattle and communal/small-scale resettlement (non-commercial) cattle respectively, that will be covered by such self-financing practices under the different distance scenarios being considered. The result of this exercise shows that under all scenarios of practice area, existing facilities that are likely to be self financing would cover a higher proportion of the commercial cattle than cattle belonging to communal farmers. It is particularly important to note that if the current average practice area of 35 kilometre radius (as derived from the survey) is maintained, any privatisation exercise involving existing veterinary facilities that would be self financing would cover about 70% of commercial cattle, but only about 36% of communal cattle in Zimbabwe. This implies that the remaining national herd would require some form of subsidy or other policy options, in order to be served. It is important to note at this point that, what constitutes a practice area (i.e. distance to be covered by a practice) varies from practice to practice and depends on the marginal cost of travel to any particular farm. The survey of practitioners in Zimbabwe carried out in this research suggests an average practice area of 35 km radius, but range from 25 km to 45 km. Where the policy of contracting out of services by the government exists, such as in vaccination campaigns, it is usually possible for the government or the implementing body to stipulate the specific area to be covered by each practice participating in the scheme, since such travel costs will be subsidised. This model would therefore be very useful in such cases. On the other hand, where practices operate independently, the potential coverage of the different practice areas can easily be computed as well, using the model. As was discussed in Chapter 4, the survey of various producer types in Zimbabwe does not show any significant relationship between distance of farms from veterinary clinics and uptake of veterinary services (Vet-visit). It does appear that in the event of privatisation, the important decision of the boundaries to be covered by a facility (distance between veterinary practice and farmer or practice area), would be taken by the veterinary practices based strictly on travel cost (time and money) considerations.

Although a particular facility or location may emerge financially viable according to this model, veterinary practitioners often engage in optimisation decisions involving choices between the proportion of livestock belonging to the different production systems available within their practice areas. Such a decision is not based on the distance between farm and clinic alone, but also on the veterinary expenditure per head of cattle for the different production systems, the number of cattle to be treated per visit and the type of services demanded. As was shown in Table 6.5, these determinants vary between the various production systems in Zimbabwe. Thus for instance, a practice with a notional catchment comprising of 10,000 heads of commercial and communal cattle each, will be involved in a decision process as to what combination of the two populations of cattle to treat, based on practice objective to maximise profits, limitations being time and other practice resources. In its present form, the L-A model cannot resolve this problem. However, L-A outputs can be linked to other models of practice decision optimisation models such as a Linear Programming models. These can help predict the optimum combination of the two livestock populations which will ensure maximum profits for the practice, under different policy and socio-economic constraints. Such L-P model will be addressed in the next chapter.

6.6 Conclusion: (Summary, limitations and model validation)

The main objective of this chapter was to explore the locational efficiency as well as issues relating to the equity and viability of existing and planned policies on the allocation of clinical facilities in Zimbabwe. To this end, various capabilities of the L-A model were used in the evaluation of the delivery of animal health services. The working hypothesis being that the spatial distribution of existing clinical facilities in Zimbabwe can be improved thereby bringing about greater efficiency and equity. Efficiency and indeed equity of access here derive from the principle that the whole population should be given equal opportunity to receive health care services. Since spatial availability of a facility is a prerequisite for utilisation and hence access, it follows then that efficiency and equity of access are best achieved when the spatial distribution of facilities ensures that the whole population enjoy the best possible and similar level of access. Location-allocation theory provides four objectives for models developed to resolve problems relating to access to central facilities which serve dispersed populations:

1- Minimise aggregate /mean travel distance to facilities by total population

2- Minimise maximum travel distance by populations farthest away from facilities

3- Maximise population covered by facilities

4- Minimise total distance covered subject to a specified distance constraint

The choice of model for this study, GRAFLOC, is implemented using algorithms which achieve the first objective, which is to minimise the aggregate travel distance for the whole population. This objective is perceived to be the most equitable of the four even though it may accentuate the maximum travel distance for a few members of the population. The output data from the model permit the evaluation of a population in terms of the proportion allocated to each facility and the mean and aggregate travel distances of the populations allocated to each facility. It is thus possible to evaluate matters relating to efficiency of allocation and thus, efficiency of access for the whole population under different policy scenarios.

Three null hypothesis were to be addressed by this chapter, the first being that, the spatial distribution of existing veterinary facilities in Zimbabwe is inherently inefficient. The second suggest inequity while the third evaluates the issue of viability of the various facilities in their present locations. All of the issues addressed by the three null hypothesis are most topical and relevant to the current debate on privatisation and the reform of the health care delivery system in Zimbabwe. Comparing scenarios 1 and 2, as well as scenarios 5 and 6 of our modelling exercise permits the evaluation of the relative efficiency of the existing locations of veterinary facilities for small animal practice in Harare, and the national herd respectively. These look specifically at locational efficiency with regards to the aggregate /or mean travel distance of the population as compared to more optimum relocation alternatives as derived by the model.[10] The results of the analysis show a possible 65 percent and 27 percent improvements on existing locations for the Harare small animal practices and the national herd facilities respectively. The first

[10] Locational efficiency here is determined as in Ayeni et al (1987), where alternative facility locations are compared in terms of how many more people will be closer to the facility under the different location scenarios.

null hypothesis on inefficiency with regards to existing policies on allocation of clinical facilities is thus clearly upheld by these results.

Testing the second null hypothesis which relates to the inherent inequities in the existing locational policies involves comparing how the various socio-economic strata of the population are served under different scenarios. Once again the null hypothesis is upheld, confirming inherent inequities. It emerged for instance that existing locations (Scenario 1) favour high income house holders in Harare who only travel about three kilometres to their nearest clinic, and less so middle income householders who travel about four kilometres. Low income householders are particularly disadvantaged as they travel on the average, about nine kilometres when they visit their nearest veterinary clinic. The analysis of the national herd done on the basis of commercial and non-commercial producers shows that, while commercial producers incur on the average, travel cost equivalent of twenty five kilometres when visiting their vet, or vis-versa, non-commercial (communal and small scale resettlement farmers) incur about thirty five kilometres equivalence in travel costs. In either case (Harare and national herd), it has emerged that there is inequity in the current allocation systems, and in particular, that poorer strata of the community are disadvantaged and penalised by the inherent locational inefficiency of the system. It should be noted here that although travel costs computed by the model refers to visits made by each member of the population, the output can be adjusted to reflect the more common scenario where the veterinarian visits the herds. Although the actual aggregate travel distance will change, the conclusions with regards to efficiency and equity will still remain the same.

The third null hypothesis addresses the viability or otherwise of the various national clinical facilities and involves the use of the population allocated to each facility (scenario 5) by the model and economic figures derived from field survey of the two livestock producer groups in Zimbabwe. A facility is perceived to be viable if income generated by the allocated population within the practice catchment area (35 km) can sustain a typical Zimbabwean private practice using a decision analysis involving a calculated viability coefficient. The measure of viability is the Practice Viability Index (PVI) and a facility with PVI greater than one is perceived to be viable (Odeyemi, 1993). On the basis of this study, the third null hypothesis is upheld for some of the facilities and not for others. This of course is expected as some facilities are likely to be able to sustain private practices while others would not. Unfortunately, once again it has emerged that under all scenarios of practice area, self-financing private practices would cover more of the commercial livestock producers compared to non-commercial (rural) livestock producers covered. This has significant policy implications especially with regards to the privatisation policy. This study permits a policy of selective targeting. For instance whole scale privatisation facilities which are self-financing and the subsidisation of those facilities which are not self-financing could be recommended. There are three major limitations to the current study:

1- The choice of locational efficiency amongst several possible properties of service delivery.

2- The property of the model used which is based on Euclidean geometry (straight line) rather than network space (existing road networks).

3- The character of the population data used which assumes static populations with inelastic demand.

Locational efficiency is the easiest efficiency measure in the evaluation of a delivery system and, although it may not necessarily be the most important efficiency problem being encountered. However, it is the most prone to abuse due to political administrative districting systems of locating service centres especially in goods delivered by the public sector. When provision of such publicly delivered goods are to be privatised, as is the case with animal health services in Zimbabwe, it becomes imperative to correct the inherent inefficiencies and inequities within the existing location of supply centres. Furthermore, although other measures of inefficiency such as official corruption and beaurocracy within a delivery system are rather more obvious, their occurrence and courses vary widely between systems, and often do not subject themselves to clear empirical analysis as is the case with locational efficiency. It should thus be stated clearly that this study specifically addresses locational efficiency and does not by any means suggest or rank this attribute over other efficiency measures within the delivery system in Zimbabwe. The second limitation which is the choice of Euclidean space over network models was made just so as to simplify the analysis. It has emerged in a lot of studies that analysis based on network geometry are not necessarily more accurate in every occasion. This is due in part to the detailed information, often not available, which is required for network models, such as the character of the various roads in the network. Thus the effects of different seasons, road gradients, availability of transport, terrain, natural barriers (etc.) all suddenly become important. It is thus debatable in view of the potential errors likely to be introduced into the analysis by the quality of data used, whether network models are superior. Furthermore, the estimate provided in this case, by the Euclidean geometry model is adequate for highlighting the various issues raised in this study.

Finally, the inelastic demand assumed for this study is based on a partial equilibrium analysis, where the principle of "ceteris paribus" prevails. In other words, all other market variables are assumed to remain unchanged. Thus, no attempt has been made in this study to evaluate changes to demand (consumption) or prices, when other socio-economic variables change under the different policy scenarios. It is sufficient to mention here that, in real economic systems, such as the health care delivery, any economic policy disturbance such as privatisation would have a chain reaction affecting itself and other products in the market place. In the following chapters, Linear Programming (LP) models will be developed to look at the behaviour of practitioners under different policy scenarios such as privatisation.

CHAPTER 7

MODELLING OPTIMISATION DECISIONS FOR FARM ANIMAL VETERINARY PRACTICES IN ZIMBABWE.

7.1 Introduction

Experience from other sectors of the agricultural industry of many countries suggests that a shift, from public delivery to privatisation or commercialisation of services, is expected to necessitate changes in the structure of delivery of the services. This, it is thought, could be far-reaching and may involve changes to the variety of services provided. Similarly, the nature of clientele served as well as the types and sizes of personnel and other resources and infrastructure needed to deliver the services may need to be changed (Dinar, 1996). Several workers have predicted similar changes for the delivery of animal health services in Africa. Of particular concern has been what the behaviour of private sector service providers would be in the light of their profit maximisation objectives, and how this would affect their decision as to what combination of services to provide and which clientele to serve. A recurring theme in every privatisation debate has thus been the twin issues of the viability and sustainability of services following privatisation vis-à-vis equity related concerns that, resource poor farmers will be denied access and be further marginalised by profit maximising service providers. The potential for involving lower level professionals or paraveterinarians as alternatives to, or in combination with, professional veterinarians has introduced possible scenarios that equally require the attention of planners and administrators. Three research questions thus emerge from the above discussions, and these would be viewed in relation to Zimbabwe:[1]

1- What proportion of existing or planned veterinary facilities are going to be viable or economically self-financing?

[1] The words "self-financing" and "self-sustaining" are used interchangeably in this chapter, and are preferred over the word "profitability". This is intentional and is intended to emphasize the relativity and subjectiveness of the word profitability where practice viability is concerned.

2- What will be the demographic characteristics of the population served by such self-sustaining practices?

3- How would paraveterinary involvement affect coverage, access, equity and viability of services to the various segments of the population?

From the above research questions, a number of null hypothesis can be formulated, on the basis of the decisions and choices that will be taken by profit maximising veterinary practitioners following the implementation of a privatisation policy.

1- The livestock resources in Zimbabwe cannot sustain economically viable (self-financing) private veterinary practices in existing veterinary facilities.

2- Privatisation will result in no difference in access to veterinary services, between the different livestock producer groups in the country.

3- The introduction of an independent cadre of paraprofessionals into the delivery system will not bring about any significant change to veterinary coverage.

The framework for testing the above hypothesis revolves around activities of clinical facilities and locations in Zimbabwe. Based on optimisation decisions to be taken by private practitioners, the status of every clinical facility will be evaluated in terms of its viability. Only populations within viable or self-financing facilities will then be considered covered. LP models will be used to simulate the decision optimisation process of such profit maximising service providers. The decision will be based on the objective of maximising their income (aspirations) and minimising any costs arising, in this case travel costs. Viability or otherwise will depend on the level of income available from serving different combinations of commercial and non-commercial producers in the catchment area of each facility. Only populations within viable or self-financing facilities will then be considered covered.

7.2 Linear programming models in animal health delivery

Mathematical models and particularly linear programming modelling techniques, have received very wide usage in industry (Winston, 1995). Various applications are also documented for solving different types of farm planning problems (Dent et al, 1986, Hazell an Norton, 1986, Pitel, 1990). The economic activities of livestock producers as well as the reproductive performance of different livestock breeds have been modelled extensively (Rehman and Romero, 1984, Huirne et al, 1992, 1997, Jalvingh et al, 1997). Similarly, the behaviour, the control and the economic impact of various livestock diseases have also been modelled (James, 1977, Christiansen and Carpenter, 1983, Habtemariam et al, 1984, Carpenter and Howitt, 1988, Galligan et al, 1988, Ngategize, 1996). Mathematical modelling techniques have found use in the allocation of resources for human health care delivery (Stinnett and Paltiel, 1996). However, the work by Christiansen and Carpenter (1983), Habtemariam et al (1984), Galligan et al (1988) and Galligan and Marsh (1997), are some of the very few occasions where Linear Programming has been used in animal health. Jalvingh et al (1997) blamed this on a possible lack of familiarity with the technique.

There thus appears to be an increasing awareness of the use of mathematical programming, and linear programming techniques in particular, in the economic evaluation of animal production and health activities. There is however, no record of the use of the techniques in the modelling of the economic behaviour of the animal health care providers. This is despite of the fact that, such behaviour by providers, determine to a large extent, the success or otherwise, of any health care intervention. This is even more so, under the current dispensation of a global policy on privatisation. This study is therefore an attempt to develop a methodology for evaluating the impact of economic decisions made by health care providers on the provision of health care services.

7.3 The choice of Linear Programming model

The animal health delivery system qualifies to be studied using LP techniques. This is because, like other agricultural systems, it represents an economic entity whose behaviour is regular, predictable and goal directed, qualities essential to successful modelling exercise (Hazell and Norton, 1986, Romero and Rehman, 1989, Pitel, 1990). LP modelling essentially provides a logical and economic approach to solving a planning (LP) problem, by determining the optimal allocation of resources to competing activities. Thus, decisions are made on the choice of activities to achieve set objectives, subject to prevailing constraints arising usually from limited resources (Dent et al, 1986). Bennett (1992), lays out five conditions for deciding on a choice of appropriate technique in quantitative modelling of livestock disease control decisions:

- The decision problem can be modelled
- The complexity of the system
- Information available
- Uses to which model will be made
- The resources available to the modeller.

The success of the modelling exercise and its usefulness, depends on the choice of the technique, the specification of the model, the assumptions and value of the parameters contained in it (Bennett, 1992). Bennett (1992) suggests that the mathematical modelling technique becomes appropriate where the problem can be clearly defined in terms of the objective, method of achieving the objective, and identifiable and realistic constraints. Ngategize and Kaneene (1985) lay out the types of questions such a LP model can address:

- What enterprise combinations are economical
- At what level of operation should each enterprise be maintained
- What the expected return would be from each enterprise
- The range of prices (or costs) over which particular enterprises would remain economical.

7.4 The theoretical framework for Linear Programming models

A LP model is formulated principally to solve a LP problem. As stated earlier, a LP problem is an optimisation process for which a linear objective function is either maximised or minimised subject to some constraints and sign restrictions. Thus, there are four major components to a LP model (Dent and Blackie, 1979, Winston, 1995):

1- Objective function- This is the function to be either maximised or minimised such as costs or profit.

2- Decision variables- These are statements that describe the decisions that needed to be addressed.

3- Constraints- These are restraints to which the decision variables are subjected. These must be linear equations or inequalities and will be either binding or non-binding when optimal values of the decision variables are substituted into the constraints.[2]

4- Sign restrictions- These are the signs that the values are allowed to assume. Variables are either made to assume non-negative or unrestricted signs.

There are four assumptions which must be valid for every LP problem being modelled (Hazell and Norton, 1986, Winston, 1995):

1- Proportionality assumption- This requires that the combination of each decision variable should be proportional to the value of the decision variables.

2- Additivity assumption- The contribution of any variable to the objective function must be independent of the values of other decision variables.

3- Divisibility assumption- This indicates that each decision variable is allowed to assume fractional values. If only integer variables are allowed, then the assumption will not hold.[3]

4- Certainty assumption- This demands that, each constituent variable of the LP problem, such as the objective function and the other variables, must be known with certainty.

7.5 Privatisation in Zimbabwe as a Linear Programming problem

The policy of privatisation of animal health delivery in Zimbabwe has created a dilemma for policy planners and professionals alike. At the national level, the problem is aptly captured by the three null hypothesis described at the beginning of

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[2] The constraints are said to be binding when the left hand side of the equation is equal to the right hand side. They are not binding when the two sides are unequal.

[3] Integer programming techniques have been developed specifically to handle problems involving integer variables.

this chapter. They relate to the effect of privatisation on the viability and sustainability of facilities and services, as well as the consequential veterinary coverage or its absence, that will result especially where competition is permitted between different cadres of professionals. At the individual clinical facility level, the above problem translates into a dilemma for private practitioners. They are now required to decide on what choice or combination of livestock producers to serve, in order to achieve their profit maximisation objective. In economic terms, they are expected to weigh the opportunity cost of serving the different livestock producer groups (clientele), in the light of their income aspirations and the costs (travel) they are likely to incur. Such a decision of course is subject to, and constrained by, the total livestock population within their practice area or catchment. The methodology adopted for this study is similar to the steps in Linear Programming as suggested by Rae (1994) and Winston (1995). Viz.:

- Identification of the LP problem.
- Written description of relationship.
- Arithmetic representation of description.
- Organisation of arithmetic statements into LP format.

The dilemma facing veterinary professionals as earlier described for Zimbabwe, can thus be presented in a simplified LP problem. The practice income and cost of providing services are considered as the production activities. These values are computed for populations living within four distance rings around each practice, viz., 0 to 25, 25 to 35, 35 to 45, and greater than 45. In fulfilment of the Linearity Assumption, the various activities in the LP matrix are considered independent of each other (Additivity Assumption), and their contribution to the LP solution proportional to the individual values of the activities (Proportionality Assumption). Furthermore, the units of the aspiration levels computed are allowed to take on fractional values in fulfilment of the Divisibility Assumption for LP models. The coefficients for the various variables are derived from real-life survey data of Zimbabwe, thus satisfying the Certainty Assumption for LP models.

7.6 The privatisation scenario

7.6.1 Designing the LP matrix

Under the privatisation policy, it is proposed that the government will withdraw from the provision of clinical services by privatising all veterinary clinics and facilities especially where such facilities are viable. The government is also expected to discontinue subsidy for privately inclined goods, of which the dip subsidy is the most important in Zimbabwe. It is however expected that the government will continue to pay for publicly inclined goods such as vaccination for Foot and Mouth Diseases in communal (non-commercial) cattle. This is important, if the beef export trade from Zimbabwe is to be maintained. The government is likely to contract this service out to private practitioners. The competing role of paraveterinarians in a privatised delivery system is also being discussed and needs to be examined.

Modelling the above scenario of the delivery system essentially involves looking at the entire delivery system, but in terms of its constituent units, which are the individual clinical facilities. Each facility is then viewed as a profit maximising enterprise, whose objective function would be to maximise its viability, or the net income generated over its practice area or catchment. The income generating potential of each facility would therefore determine whether the facility is viable or not (Odeyemi, 1993, 1996). The production activities that would provide income for the practices are the various livestock herds that fall within each practice area (catchment). For this Zimbabwean case study, it has already been determined in Chapter 4 that, there are two types of livestock producer groups in Zimbabwe, viz. Commercial and Non-commercial (or smallscale) farmers. The result also provides the potential income (veterinary expenditure) per head of cattle for each producer type. Thus, the sum of the expenditure per head of livestock for the different producer groups within the catchment would constitute the potential income of any particular facility or clinic.[4] The expenditure per head figures will need to be

[4]In estimating the potential income of a private practice in an area, the choice of producer veterinary expenditure data is advocated over any income inventory from any existing practices in the area. Earlier work by author suggests that the former is more readily accessible and probably more accurate than the latter (Odeyemi, 1993, 1996).

adjusted so as to reflect the privatisation scenario. Because these figures were made possible by a 75 percent subsidy on dipping fees which amounts to Z$9, this amount has to be deducted to reflect a 0 percent subsidy, which will be the case with privatisation.

However, there are two other sources of additional income available to private practitioners under the privatisation scenario. A possible income equivalent to the marginal Willingness-To-Pay (WTP) value as computed in Chapter 6, is accessible to practitioners as latent demand for their services. Secondly, contracting-out of vaccination against Foot and Mouth Disease among non-commercial livestock producers, would also raise an estimated income of Z$5 per head of non-commercial livestock. The determination of what livestock population fall within which clinic catchment, has been facilitated by the use of the Location-Allocation model in Chapter 6. Because these livestock are distributed over space even within each catchment, different additional costs in travel will be incurred, in providing the income generating services to the producers. Travel cost is a major economic variable in the provision of clinical services. Because of the possible disparity in distances between different populations allocated to the same facility, the livestock population allocated to each facility is further aggregated into four. This is based on where their location falls, within four concentric distance rings (25 km, 35 km, 45 km, >45 km), drawn around the facility. Thus travel cost is calculated based on the distance ring within which a livestock unit falls. A simplified LP problem can thus be presented in a matrix form as below (Table 7.1)[5]..

However, travel costs for paraveterinarians are computed using a fixed rate equivalent to a distance of 12 km. This is based on the fact that paraveterinarians reside closer to the communities they serve, and a 12 km distance was found during

[5] The EXCEL SOLVER was the software of choice for this study mainly due to its ease of use and wide availability. This will facilitate transfer of the technology to planners in developing country institutions.

the survey as the average. On the basis of the above, our linear programming problem for each veterinary clinic or facility could be described as follows:

1- The objective function to be maximised is the number of self-sustaining professionals (Practice Viability Index). Two types of professional cadres are presented in the model, and are differentiated and constrained by their income aspirations in the model.

2- The decision variables are the population of commercial and non-commercial producers served by the clinics.

3- The constraints for the LP problem are the populations of the commercial and non-commercial producers within the different distance rings, their various income generating potentials and the travel costs to be incurred in providing them with a service. It is important to note that while the travel cost incurred per head of any producer type varies with the distance rings, the income generating potential remains the same across all distances.

Table 7.1
A Simplified Linear Programming Matrix for the Privatisation Problem for one Clinical Facility in Zimbabwe.

Objective	Ring1 Income	Ring1 Cost	Ring2 Income	Ring2 Cost	Ring3 Income	Ring 3 Cost	Ring 4 Income	Ring 4 Cost	Vet. Practice Units		KADOMA
Activity level	1	1	1	1	1	1	1	1	1	0	
Maximise	+a	-b	+c	-d	+e	-f	+g	-h	0	0	max
Constraints											
Rg1 Income	1	-1								≤	0
Rg1 Population	1									≤	i
Rg2 Income			1	-1						≤	0
Rg2 Population			1							≤	j
Rg3 Income					1	-1				≤	0
Rg3 Population					1					≤	k
Rg4 Income							1	-1		≤	0
Rg4 Population							1			≤	l
Vetcost	+a	-b	+c	-d	+e	-f	+g	-h	-1015133	=	0

Where:
- a, c, e and g are the income activities (veterinary expenditure) of the livestock producer groups in rings 1 to 4.
- b, d, f and h are the additional costs (in travel) incurred in providing the services to the livestock populations in rings 1 to 4.
- i, j, k and l are the total livestock population (commercial and non-commercial) within the distance rings 1 to 4 respectively.
- VetPUnit represents the objective function and Vetcost, the income aspiration required to achieve the objective.
- Kadoma is the facility name

7.6.2 Computing the Coefficients of the LP variables

The LP matrix for modelling the activities of each facility under different scenarios, comprises of four sectors each, for professional and paraprofessional practitioners. In addition, there is also a column each, for the professional and paraprofessional income aspirations (Table 7.3). Each professional veterinary sector comprises seven variables. Five of these variables represent income generating activities, while the other two represent cost activities. Each paraveterinary sector on the other hand, comprises four variables. Three of the variables represent income activities and the remaining one represents a cost activity. The value of the coefficients of each income activity is the same across all four sectors for the same activity. However, the values of the cost activities vary with each sector, as it is related to the Maximum Travel Distance (MTD) of each particular sector. The values of the income activities are computed from the results of the field survey as summarised in the table of descriptive summaries in Chapter 6 (Table 6.1b).

The coefficients of the various income activities are computed as follows: [6],[7]

1- Commercial Cattle Income (CFInc)

= Average Vet. Expenditure /Average Herd size

2- Non-commercial Farm Income (Sfinc)

= Farm Vet. Expenditure / Average Herd size

3- Commercial farm WTP (Cfwtp)

= (WTP - Total Expenditure) /Average Herd size

4- Non-commercial farm WTP (Sfwtp)

= (Farm WTP - Total Expenditure) /Average Herd size

5- Foot and Mouth Disease Subsidy (SFfmd), is derived from the Department of Veterinary Services' estimate of about Z$5, and is applied only to Non-commercial cattle.

[6] Presence of missing values in some of the cases in the data base may result in slight differences in the calculation of the income (expenditure) values using figures in Table 6.1b. For instance, CFinc and SFinc are computed to be 46.41 and 11.76, instead of 54.58 and 10.49 respectively.

[7] Computing removal of dipping subsidy for Cfinc and Sfinc in the various scenarios simply involve, deduction of the monetary equivalence of the percentage subsidy from the base value of the variable. Thus a total withdrawal of dipping subsidy will reduce CFinc and SFinc by Z$9 each, since the service costs Z$12 per cattle and is subsidised by 75 percent.

Computing the coefficients of the cost variables involve a number of assumptions or factors, not considered in the income calculations:

1- Veterinarians visit farms rather than farmers taking their cattle to the clinic.

2- The number of vet. visits to Commercial and Non-commercial farms per year is 6.58 and 6.17 respectively (Chapter 6, Table 6.1b).

3- Each visit (return journey), costs the equivalence of twice the Maximum Travel Distance of the sector (distance ring) to which the livestock population belong.

4- The average cattle herd size for Commercial and Non-commercial livestock producers is 344.16 and 19.92 respectively.

5- On the average, a veterinarian will treat about 200 cattle per visit, thus each livestock, share's 1/200th of the cost of a visit.

6- Each kilometre travelled, costs the veterinarian about Z$4.

On the basis of the above information, the annual travel cost per animal, incurred by a Commercial farmer residing in Sector 1 (distance ring 0-25 km), can be computed as follows:

Cost of Vet. Visit per head of cattle =

(MTD * 2 (return) * Z$4 (per km) Annual herd visit /cattle)/ Visit Equivalence /Herd size

or

$$\{(25) * (2) * (4) * (6.58/344.16)\}/(200/344.16) = 6.9$$

The method of computing the Income Aspiration (Viability Coefficient) for the professional veterinarian has been described in Chapter 6. Income Aspiration is thus computed as follows:

Expected Partner's Salary + Avg. Running Costs + Avg. Drug/ Input Sales

Table 7.2 below, compares the components of the Income Aspirations of the Professional veterinarian and that of the Paraveterinarian. The data on which the calculations of the Income aspirations of the Professional veterinarian is based, comes from the survey of private veterinarians in Zimbabwe between 1995/ 1996.

For the paraveterinarian, the expected salary is arbitrarily fixed at the lowest starting salary for fresh graduates, while their running costs are fixed at a quarter of that of the veterinarians.[8] Because of the lower value of the type of veterinary input required by the non-commercial producers, the veterinary drug and input component for paraveterinarians is fixed at 30 percent of other costs, as opposed to 40 percent in the case of veterinarians.

Table 7.2
Elements of the Practice Income Aspirations of the Professional and Para-veterinarians.

	Professional Veterinarian	Paraveterinarian
Expected Partners Salary	Z$ 122,000	Z$ 48,000
Running Costs	Z$ 487,200	Z$ 121,800
Drug & Input Sales	Z$ 406,133	Z$ 50,640
Practice Income Aspiration	**Z$ 1,015333**	**Z$ 220,440**

Table 7.3 provides a description of the income and cost generating activities in a facility where all dipping subsidies have been withdrawn. The LP problem for the whole country would therefore be formulated as the LP problem for individual practices repeated for all the practices and facilities in the country. The objective function of the model would be to maximise the number of viable professional and paraveterinary practices sustained in the country. This relationship can be represented by the following equations:

Max Z (Provets + Paravets)

subject to:

$IncRgi_{(i=1 \text{ to } 4)}$: $Inci - Costi \leq 0$

$PopRgi_{(i=1 \text{ to } 4)}$: $Inci \geq Pi$

Vetcost : $\sum_{i=1}^{4}(Inc_i) - \sum_{i=1}^{4}(Costs_i) - VetAspirations = 0$

[8] This level of paraveterinary income aspiration is still rather high. This is however intentional, mainly to accomodate the middle ground that will be occupied by intermediate technicians and fresh graduates.

Table 7.4 presents a fully laid-out LP matrix for one of the clinic locations. Columns 2 to 29 of Table 7.4 represent activities open to the professional veterinarians in the catchment, while Columns 30 to 46 represent activities open to the Para-veterinarians.

Table 7.3

Privatisation Scenario with 0 Percent Dip Subsidy, and 100 Percent FMD Subsidy : Description of the Coefficients of LP Model Activities for a single facility Computed for Zimbabwe.

LP Code	Description	Coeffs. (Z$)
Rg1CFin	Ring 1 commercial farmers (livestock) veterinary expenditure	37.41
Rg1SFin	Ring 1 Small scale farmers (non-commercial livestock) veterinary expenditure.	2.76
Rg1CFwtp	Ring 1 commercial farmers latent demand (marginal WTP) values	7.78
Rg1SFwtp	Ring 1 small scale farmers latent demand (marginal WTP) values.	1.85
Rg1SFfmd	Ring 1 small scale farmers Foot and Mouth Disease vaccination fees.	5
Rg1CFtc	Ring 1 commercial farmers additional travel costs.	-6.9
Rg1SFtc	Ring 1 small scale farmers additional travel costs.	-8.4
Rg2CFin	Ring 2 commercial farmers (livestock) veterinary expenditure	37.41
Rg2SFin	Ring 2 Small scale farmers (non-commercial livestock) veterinary expenditure.	2.76
Rg2CFwtp	Ring 2 commercial farmers latent demand (marginal WTP) values	7.78
Rg2SFwtp	Ring 2 small scale farmers latent demand (marginal WTP) values.	1.85
Rg2SFfmd	Ring 2 small scale farmers Foot and Mouth Disease vaccination fees.	5
Rg2CFtc	Ring 2 commercial farmers additional travel costs.	-9.7
Rg2SFtc	Ring 2 small scale farmers additional travel costs.	-11.8
Rg3CFin	Ring 3 commercial farmers (livestock) veterinary expenditure	37.41
Rg3SFin	Ring 3 Small scale farmers (non-commercial livestock) veterinary expenditure.	2.76
Rg3CFwtp	Ring 3 commercial farmers latent demand (marginal WTP) values	7.78
Rg3SFwtp	Ring 3 small scale farmers latent demand (marginal WTP) values.	1.85
Rg3SFfmd	Ring 3 small scale farmers Foot and Mouth Disease vaccination fees.	5
Rg3CFtc	Ring 3 commercial farmers additional travel costs.	-12.4
Rg3SFtc	Ring 3 small scale farmers additional travel costs.	-15.1
Rg4CFin	Ring 4 commercial farmers (livestock) veterinary expenditure	37.41
Rg4SFin	Ring 4 Small scale farmers (non-commercial livestock) veterinary expenditure.	2.76
Rg4CFwtp	Ring 4 commercial farmers latent demand (marginal WTP) values	7.78
Rg4SFwtp	Ring 4 small scale farmers latent demand (marginal WTP) values.	1.85
Rg4SFfmd	Ring 4 small scale farmers Foot and Mouth Disease vaccination fees.	5
Rg4CFtc	Ring 4 commercial farmers additional travel costs.	-18.4
Rg4SFtc	Ring 4 small scale farmers additional travel costs.	-40.1
PRg1SFin	Paravets Ring 1 Small scale farmers (non-commercial livestock) veterinary expenditure.	2.76
PRg1SFwtp	Paravets Ring 1 small scale farmers latent demand (marginal WTP) values.	1.85
PRg1SFfmd	Paravets Ring 1 small scale farmers Foot and Mouth Disease vaccination fees.	5
PRg1SFtc	Paravets Ring 1 small scale farmers additional travel costs.	-4.1
PRg2SFin	Paravets Ring 2 Small scale farmers (non-commercial livestock) veterinary expenditure.	2.76
PRg2SFwtp	Paravets Ring 2 small scale farmers latent demand (marginal WTP) values.	1.85
PRg2SFfmd	Paravets Ring 2 small scale farmers Foot and Mouth Disease vaccination fees.	5
PRg2SFtc	Paravets Ring 2 small scale farmers additional travel costs.	-4.1
PRg3SFin	Paravets Ring 3 Small scale farmers (non-commercial livestock) veterinary expenditure.	2.76
PRg3SFwtp	Paravets Ring 3 small scale farmers latent demand (marginal WTP) values.	1.85
PRg3SFfmd	Paravets Ring 3 small scale farmers Foot and Mouth Disease vaccination fees.	5
PRg3SFtc	Paravets Ring 3 small scale farmers additional travel costs.	-4.1
PRg4SFin	Paravets Ring 4 Small scale farmers (non-commercial livestock) veterinary expenditure.	2.76
PRg4SFwtp	Paravets Ring 4 small scale farmers latent demand (marginal WTP) values.	1.85
PRg4SFfmd	Paravets Ring 4 small scale farmers Foot and Mouth Disease vaccination fees.	5
PRg4SFtc	Paravets Ring 4 small scale farmers additional travel costs.	-4.1
Paravet	Paraprofessional practice income aspiration (Paravet Practice Viability Index)	-220440
Provet	Professional veterinary practice income aspiration (Provet Practice Viability Index)	-1015133

The LP matrix in Table 7.4 will be repeated for all 63 practice facilities in the country (See Appendix 2.4 for disk copy of LP model).

Table 7.4.
Linear Programming Matrix for Karoyi under Privatisation Scenario 1.

Objective	Rg1CFin	Rg1SFin	Rg1CWT	Rg1SFwt	Rg1SFfm	Rg1CFtc	Rg1SFtc	Rg2CFin	Rg2SFin	RG2CWT	Rg2SFwt	Rg2SFfm	Rg2CFtc	Rg2SFtc	Rg3CFin	Rg3SFin	RG3CWT	Rg3SFwt	Rg3SFfm	Rg3CFtc	Rg3SFtc	Rg4CFin	Rg4SFin	RG4CWT
Activity le	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Constraints																								
1CFpop	1																							
1SFpop		1																						
2CFpop								1																
2SFpop									1															
3CFpop															1									
3SFpop																1								
4CFpop																						1		
4SFpop																							1	
1CFin	1					-1																		
1SFin		1					-1																	
1CFwtp	1		-1																					
1SFwtp		1		-1																				
1SFfmd		1			-1																			
2CFin								1					-1											
2SFin									1					-1										
2CFwtp								1		-1														
2SFwtp									1		-1													
2SFfmd									1			-1												
3CFin															1					-1				
3SFin																1					-1			
3CFwtp															1		-1							
3SFwtp																1		-1						
3SFfmd																1			-1					
4CFin																						1		
4SFin																							1	
4CFwtp																						1		-1
4SFwtp																							1	
4SFfmd																							1	
p3SFin																								
p4SFin																								
P1SFin																								
P2SFin																								
P1SFwtp																								
P1SFfmd																								
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P2SFfmd																								
P3SFwtp																								
P3SFfmd																								
P4SFwtp																								
P4SFfmd																								
CVetcost	37.41	2.76	7.78	1.85	5	-6.9	-8.4	37.41	2.76	7.78	1.85	5	-9.7	-11.8	37.41	2.76	7.78	1.85	5	-12.4	-15.1	37.41	2.76	7.78
PVetcost																								

Table 7.4.
Linear Programming Matrix for Karoyi under Privatisation Scenario 1.

Rg4SFwt	Rg4SFfm	Rg4CFtc	Rg4SFtc	PRg1SFin	PRg1SFw	PRg1SFf	PRg1SFtc	PRg2SFin	PRg2SFw	PRg2SFf	PRg2SFtc	PRg3SFin	PRg3SFw	PRg3SFf	PRg3SFtc	PRg4SFin	PRg4SFw	PRg4SFf	PRg4SFtc	Paravet	Provet		karoyi	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	max	
																						<	39395.5	0
				1																		<	1372.02	0
																						<	0	0
								1														<	21609.2	0
																						<	11391.5	0
												1										<	26411.3	0
																						<	0	0
																1						<	44933.5	0
																						=	0	0
																						=	0	0
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												1		-1								=	0	0
																1	-1					=	0	0
																1		-1				=	0	0
1.85	5	-18.4	-40.1																		-1015133	>	0	0
				2.76	1.85	5	-4.1	2.76	1.85	5	-4.1	2.76	1.85	5	-4.1	2.76	1.85	5	-4.1	-220440		>	0	0

In order to address the three null hypothesis advanced at the beginning of this chapter, two policy scenarios are modelled:

- Privatisation Scenario 1. Only professional veterinarians will be allowed to practice without competition from paraveterinarians. This currently represents the advocated privatisation scenario in most African countries including Zimbabwe.
- Privatisation Scenario 2. Allowing paraprofessionals to compete with professional veterinary surgeons for providing services to Smallscale non-commercial producers. To achieve this scenario, substitute the "0" in Column 46, Row 3, with "1". This activates the Paraveterinary activities in Columns "30" to "46". This is a policy option that is under consideration, and the merits of which require investigation.

A number of assumptions are made, which are specific to the above two scenarios. In all, these relate to the need for accurate data to ensure that the model prediction is reliable and useful. The assumptions include the followings:

1- The latent demand (Willingness-to-pay) values invoked is valid.
2- The Foot and Mouth Disease vaccinations are contracted out by the government.
3- The introduction of competing Paraveterinarians is an acceptable policy option.
4- The coefficients used are appropriate, including the income aspiration levels.

7.7 Results of LP modelling exercise

The output of this LP modelling exercise on the delivery of animal health services is expected to be used in the following ways:

1- Identify those producers that are likely to be served by each health facility.
2- Identify those facilities that are likely to be self-financing. These are facilities whose minimal income aspiration is met, in other words, have Practice Viability Index (PVI) greater than 1.
3- Estimate population of various producers likely to be covered (by self-financing facilities), and the economic value of the services.[9]

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[9] A population is perceived to be covered if the facility serving it is self-financing. The argument being that, private practitioners are unlikely to take over facilities that are not self-financing, hence populations within such areas will not be served and their demand will remain un-met.

Table 7.5

LP Model Results of Zimbabwe's Privatisation Scenario 1.

LOCATION	COMMERCIAL.LIVESTOCK POP.	NON-COMMERCIAL LIVESTOCK POP.	PROVET
MVUMA	137330	1372	5.1
HARARE	89549	7203	3.2
MARONDERA	80847	17836	3
MACHEKE	69772	15778	2.6
INYATHI	79582	3773	2.4
CHIVHU	61861	23324	2.2
CHINHOYI	62969	0	2.2
MHANGURA	57906	343	2.1
KAROYI	50786	1372	1.9
MBERENGWA	64868	4802	1.9
BEATRICE	50786	18522	1.9
GWERU	50312	0	1.8
CHEGUTU	46673	0	1.7
MWENEZI	41926	0	1.6
MVURWI	41926	1029	1.5
KADOMA	38287	2744	1.4
SHURUGWI	41452	10976	1.4
BINDURA	37813	4459	1.4
WEDZA	33225	45619	1.3
RUSAPE	35598	25725	1.3
ESIGODINI	30377	9947	1.2
CHIPINGE	32117	5831	1.1
PLUMTREE	33857	0	1
MUBAIRA	27687	58653	1
KWEKWE	24365	1372	0.9
BULAWAYO	24681	2401	0.9
MASVINGO	24206	2058	0.9
NYAMANDHLOVU	20409	6174	0.8
RAFFINGORA	21042	0	0.8
CHIREDZI	20409	3430	0.8
GUTU	18511	61054	0.7
MUTASA	16928	34300	0.7
WEST NICHOLSON	22624	9947	0.6
ZVISHAVANE	17561	18179	0.6
CENTENARY	14555	5145	0.5
GWANDA	11075	13720	0.4
KEZI	10442	11662	0.4
GURUVE	9018	9947	0.4
NYANGA	7436	18865	0.3
FILABUSI	5695	16121	0.2
CHIMANIMANI	4588	8232	0.2
ZHOMBE	0	42532	0.1
LUPANE	1740	12348	0.1
BEITBRIDGE	2847	6860	0.1
MUREWA	0	79576	0.1
MUTOKO	791	50764	0.1
ZAKA	0	54880	0.1
CHIVI	2847	0	0.1
MUTARE	1898	13720	0.1
BUHERA	0	81634	0.1
SANYATI	0	26411	0
GOKWE	0	31213	0
NEMBUDZIYA	0	38759	0
HWANGE	1107	0	0
NKAYI	0	28126	0
LAZY Y RANCH	0	9604	0
BINGA	0	0	0
MUDZI	0	10633	0
MOUNT DARWIN	158	13720	0
RUSHINGA	0	7203	0
BUEHWA	0	27097	0
BIKITA	0	10633	0
NEDZIWA	0	28126	0
SYSTEM	1582464	3429352	

Table 7.6

LP Model Results of Zimbabwe's Privatisation Scenario 2.

LOCATION	COMMERCIAL LIVESTOCK POPULATION	PROVET	LOCATION	NON-COMMERCIAL LIVESTOCK POPULATION	PARAVET
MVUMA	137330	5.1	BUHERA	272345	6.8
HARARE	89549	3.2	LUPANE	194483	4.9
MARONDERA	80847	2.9	MUTOKO	156752	3.9
MACHEKE	69772	2.6	MUREWA	136515	3.4
INYATHI	79582	2.4	NKAYI	132742	3.3
CHINHOYI	62969	2.2	NYANGA	133428	3.3
CHIVHU	61861	2.1	GOKWE	128969	3.2
MHANGURA	57906	2.1	RUSAPE	119365	3
KAROYI	50786	1.9	NEDZIWA	121766	3
MBERENGWA	64868	1.9	WEDZA	116621	2.9
GWERU	50312	1.8	ZAKA	101186	2.5
BEATRICE	50786	1.8	KAROYI	94326	2.4
CHEGUTU	46673	1.7	GUTU	97070	2.4
MWENEZI	41926	1.6	MUBAIRA	93983	2.3
MVURWI	41926	1.5	NEMBUDZIYA	85064	2.1
KADOMA	38287	1.4	ZHOMBE	72030	1.8
SHURUGWI	41452	1.4	WEST NICHOLN	71001	1.8
BINDURA	37813	1.4	CHIREDZI	72716	1.8
RUSAPE	35598	1.3	CHIVHU	68600	1.7
WEDZA	33225	1.2	MACHEKE	62769	1.6
ESIGODINI	30377	1.1	MUTASA	63798	1.6
CHIPINGE	32117	1.1	KEZI	60025	1.5
PLUMTREE	33857	1.0	BUEHWA	58310	1.5
KWEKWE	24365	0.9	CHIPINGE	60368	1.5
BULAWAYO	24681	0.9	MUTARE	56252	1.4
MUBAIRA	27687	0.9	SANYATI	51450	1.3
MASVINGO	24206	0.9	CHEGUTU	46648	1.2
NYAMANDHLO	20409	0.8	BIKITA	47334	1.2
RAFFINGORA	21042	0.8	MARONDERA	45619	1.1
CHIREDZI	20409	0.8	MUDZI	45962	1.1
WEST NICHOLS	22624	0.6	CHINHOYI	43218	1.1
ZVISHAVANE	1756	0.6	SHURUGWI	41160	1
GUTU	18511	0.6	BEITBRIDGE	36358	0.9
MUTASA	16928	0.6	ZVISHAVANE	37387	0.9
CENTENARY	14555	0.5	MWENEZI	34986	0.9
GWANDA	11075	0.4	GWANDA	32585	0.8
KEZI	10442	0.4	HARARE	31899	0.8
GURUVE	9018	0.3	BEATRICE	30870	0.8
NYANGA	7436	0.3	MBERENGWA	29498	0.7
FILABUSI	5695	0.2	NYAMANDHLO	26411	0.7
CHIMANIMANI	4588	0.2	ESIGODINI	28126	0.7
BEITBRIDGE	2847	0.1	FILABUSI	24010	0.6
CHIVI	2847	0.1	LAZY Y RANCH	21266	0.5
MUTARE	1898	0.1	RUSHINGA	18179	0.5
SANYATI	0	0.0	PLUMTREE	15092	0.4
GOKWE	0	0.0	MOUNT DARWIN	15435	0.4
ZHOMBE	0	0.0	INYATHI	11319	0.3
NEMBUDZIYA	0	0.0	BINDURA	10976	0.3
LUPANE	1740	0.0	GURUVE	11662	0.3
HWANGE	1107	0.0	MASVINGO	10633	0.3
NKAYI	0	0.0	CHIMANIMANI	11319	0.3
LAZY Y RANCH	0	0.0	BULAWAYO	6174	0.2
BINGA	0	0.0	MHANGURA	8232	0.2
MUREWA	0	0.0	MVUMA	6860	0.2
MUTOKO	791	0.0	KADOMA	4116	0.1
MUDZI	0	0.0	KWEKWE	5488	0.1
MT DARWIN	158	0.0	CENTENARY	5145	0.1
RUSHINGA	0	0.0	GWERU	0	0
BUEHWA	0	0.0	HWANGE	1029	0
ZAKA	0	0.0	BINGA	1372	0
BIKITA	0	0.0	MVURWI	1029	0
BUHERA	0	0.0	RAFFINGORA	0	0
NEDZIWA	0	0.0	CHIVI	0	0
System	1582464		System	3429352	

4- Estimate the population of livestock not covered (by self-financing facilities) and the monetary equivalence of the unmet demand.[10]

5- Identify the effect of location (travel cost) on practice viability.

6- Predict the economic and social effects of paraprofessional competition on practice viability.

Table 7.5 and Table 7.6 provide details of LP model prediction on a location by location basis, for scenarios 1 and 2 respectively. Appendix 2.2 provides a sample output Answer Report and Sensitivity Analysis report, for both scenarios modelled for Kadoma, one of the 63 locations in Zimbabwe. A general summary of the answer reports for the scenarios modelled for the whole country (63 locations) is provided in Table 7.7. Scenario 1 (Table 7.7, Column 2), presents the case where only professional veterinarians are allowed to practice following privatisation. It shows that only 31 percent of the national herd of cattle will be covered by self-financing private practices. More importantly however, while 82 percent of commercial livestock will be covered, only 6 percent of the non-commercial (Smallscale and communal) livestock will be covered.

Table 7.7
Summary Results of LP Modelling of Privatisation Scenarios 1 and 2.

	SCENARIO 1 (Provet Alone)	SCENARIO 2 (Provet + Paravet)
Total Population Covered (%)	31	84
Commercial Livestock Covered (%)	82	80
Non-Commercial Livestock Covered (%)	6	86
No. of Self-Financing Veterinary Practices	46	45
No. of Self-Financing Paraveterinary Practices	N/A	74

In Scenario 2 (Table 7.7, Column 3), paraveterinarians are allowed to compete with professional veterinarians. Here, 84 percent of the national herd is covered, 80 percent of the commercial and 86 percent of non-commercial cattle is covered respectively.

[10] Estimate of un-met demand will provide a means of determining appropriate level of subsidy required, where such is a policy option.

Figure 7.1

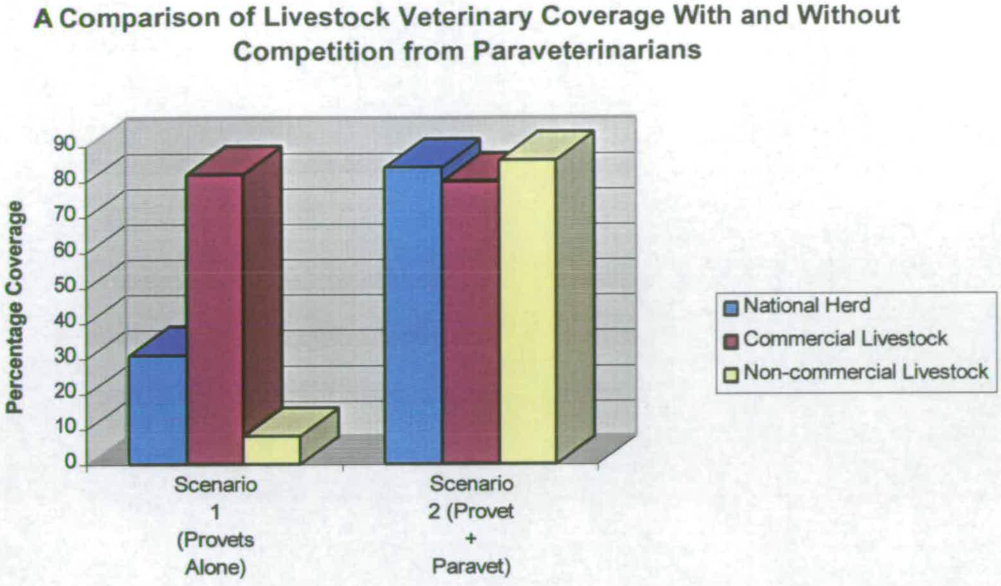

Figure 7.1. shows the dramatic improvement in veterinary coverage, from 6 percent to 86 percent, for non-commercial cattle with the introduction of paraveterinarians. Similarly, coverage for the national herd improved from 31 percent to 84 percent. It thus emerged that, competition from paraveterinarians resulted in only a slight drop in veterinary coverage (82 to 80 percent), for commercial livestock, as well as in the number of professional veterinarians, 46 to 45, sustained by self-financing clinical facilities. Scenario 2 on the other hand, produced 74 self-financed paraveterinarians, who were excluded from practice by the policy in Scenario 1.

7.8 Discussion

In trying to understand the dynamics of the provision of privatised services to livestock farmers in Zimbabwe, two Scenarios were modelled in this chapter. The scenario where only professional veterinarians were allowed to practice, and the second scenario where competition with paraveterinarians was allowed, specifically for services to smallholder producers. Scenario 1 produced 23 viable practice locations, out of the existing 63. Thus only livestock within the catchment of these practices will be covered, since only viable locations will attract a private practice. In Scenario 1, although 82 percent of commercial producers were covered, only 6 percent of non-commercial livestock were covered. The reason for such disparity becomes apparent on closer examination.

The results suggest that the viability or otherwise of any location is dependent on the size of commercial livestock in the location. For, while it is profitable to serve the commercial producers whatever their location, the marginal value of serving the non-commercial producers only exceed the marginal cost per head of livestock with producers in Ring 1. The non-commercial producers in other distance rings can only be served at a loss (i.e. Marginal cost is greater than marginal income). Another factor responsible for the low coverage for the non-commercial producers, lies in the fact that, a location is considered covered only when the whole facility is viable (self-financing). Hence, non-commercial producers located within Ring 1 of non-viable facilities, will still not be covered, despite having a marginal income greater than their marginal cost.

A second important observation, relates to the composition and monetary value of the production (income) activities of the non-commercial producers. It emerges for instance that, over 50 percent of their income comes from the Foot and Mouth Disease subsidy of Z$5, with other sources amounting to Z$4.6. Since only the non-commercial livestock in Ring 1 are profitable, and the marginal profit for serving them is only Z$1.21 per head, it is clear that any withdrawal of FMD subsidy below Z$3.8, will make all non-commercial livestock non-profitable to private professional veterinarians.[11]

The privatisation Scenario 2 involves the introduction of paraprofessionals to compete with the professional veterinarians to serve the non-commercial producers. The paraprofessionals have a lower income aspiration and are modelled to reside close to (12 km) the producers. Such a scenario as this, increased coverage for non-commercial livestock from 6 percent to 86 percent. As was the case with professional veterinary practices, a population is deemed covered if the location

[11] Income Activities (SFin + Sfwtp + SFfmd) - Travel Cost (SFtc), or (2.76 + 1.85 + 5) -(4.1) = 5.51

provides sufficient income to sustain a self-financing paraveterinarian. An analysis of the monetary value of the income activities suggests that it will always be profitable for the paraprofessional to serve the non-commercial producers (i.e. Marginal Income is greater than Marginal Costs). Thus, non-commercial livestock will always be covered by paraveterinarians, as long as there are sufficient numbers to ensure financial viability. Another important observation with regards to the results of the second scenario is that there is a slight drop both in the number of commercial livestock covered (82 percent to 80 percent), as well as in the number of self-financing veterinarians sustained (46 to 45). A closer examination of the results suggests that, the former was due to the latter. Meanwhile, the fall in the number of self-financing veterinarians was due to the fact that they have lost the income from non-commercial producers located in Ring 1 to paraveterinarians. Since the paraveterinarians have a lower income aspiration, and they reside closer to the non-commercial producers, they are able to provide the services at a lower cost.

Certain aspects of the design of the LP model itself requires mention here. Of particular importance, are the assumptions and methods used in calculating the travel cost incurred when treating each animal in the model. The assumption of treating 200 cattle per visit, is based on the average derived from interviews with existing private practitioners. Though appearing rather tortuous, the computation ensures that a realistic coefficient is derived for the travel cost incurred in providing each head of cattle in the model. While a target of 200 animals per visit is easily achievable in commercial farms, its feasibility when serving non-commercial producers appears less likely. However, achieving such a target is enhanced by several factors, one of which is intrinsic to the formulated LP model itself. Apart from the first sector (distance ring) with 25 km, the maximum distance between farms within any particular distance ring is only ten kilometres. Thus, provided there is sufficient number of herds within any particular ring, covering ten herds per visit (20 cattle per herd) should be possible. Other existing management and cultural practices also enhance the possibility of achieving the 200 target. Furthermore, management practices that encourage the congregation of animals include dipping, cattle markets, cattle crush sites etc., would facilitate attainment of 200 animals per visit coverage (Anis, 1981). However, in those areas where the cattle population within a ring, is so low and dispersed as not to support the 200 cattle per visit, would quite clearly not support viable practices.

7.9 Validation and Sensitivity analysis of Linear Programming model

7.9.1 Sensitivity analysis

Sensitivity analysis helps to monitor certain parameters in an LP model, which are of such significance that we need to be able to predict how changes to these would affect the optimal solution (Winston, 1995). For instance, income aspirations of the various cadre of professionals may change over time, either due to partners salary increasing or increase in rent or equipment replacement. Sensitivity analysis helps determine the impact of such uncertain estimates on the outcome of the solution proffered by the model (Dijkhuizen et al, 1997). The analysis involves varying the value of a key parameter and observing the degree of changes to the optimal solution (Gittinger 1982). The software used for our analysis produces a default sensitivity report which permits an assessment of each and every parameter entered into the LP model. As earlier stated, of particular interest to this study, is the ability to predict the effect of changes in income aspirations on practice viability and livestock coverage.

An evaluation of the impact of varying the income aspiration of the two professional cadres, veterinarians and paraveterinarians, can be assessed by comparing the Answer Reports of two Privatisation Scenarios for Karoyi (Appendix 2.2 and 2.3). The result shows that the model is very sensitivity to changes in income aspirations for both cadres of professionals. For instance, a 20 percent decrease in income aspiration of veterinarians (Provets) in Karoyi (Z$1,015,133 to Z$ 812,106) is shown to result in an increase in the number of Provets sustained from about 1.9 to 2.3. Thus, small to moderate changes in income aspiration, will have major impact on the model outcome. The impact of changes in income aspirations for different scenarios of combination of professional cadres for Karoyi was analysed by first increasing and then decreasing the income aspirations of the Provets and then Paravets by 20 percent respectively.

Table 7.8
Summary Result of Sensitivity Analysis of Professional Income Aspirations at Location Karoyi

SCENARIO	PROVET SUSTAINED	% PROVET CHANGE	PARAVET SUSTAINED	% PARAVET CHANGE
PRESENT LEVEL	1.85	N/A	2.35	N/A
20% INCREASE IN PROVET INCOME ASPIRATION	1.54	-17	2.35	0
20% DECREASE IN PROVET INCOME ASPIRATION	2.31	+25	2.35	0
20% INCREASE IN PARAVET INCOME ASPIRATION	1.85	0	1.96	-17
20% DECREASE IN PARAVET INCOME ASPIRATION	1.85	0	2..90	+23

N/A Not Applicable

Table 7.8 provides the picture of the changes to the number of professionals sustained following changes to the income aspiration levels. In both cases, changes in income aspiration of one provider type only affects its own viability, but not the viability of the other cadre of provider. Changes of about 20 percent magnitude in income aspiration are shown to result in changes to viability of between -17 percent to about +25 percent. Thus it can be concluded that, marginal changes in income aspiration is critical to the viability of any cadre of professional. The policy implication of this result is that, viability and hence, veterinary coverage of any private practice facility or location, will be greatly enhanced through the adoption of private practice models that have lower income aspirations.

7.9.2 Validation of LP model results

One of the major attributes of the LP model is its ability to make clear, the dynamics of a delivery system, and in particular, issues relating to efficiency and equity in resource allocation. The successful validation of the model used in this chapter, will allow us the confidence to make and accept statements about the various null hypothesis that are being tested. The purpose of any validation exercise is to investigate the validity of the model as a decision tool (Dent and Blackie, 1979, Dent et al, 1986). McCarl (1984) provides a detailed review on the subject of model validation. He distinguishes between technical validation of the model itself and operational validation, which compares model output with real-life situations. Of the two validation techniques described above, validation by results, is perceived to be more appropriate for this study and is thus adopted. The procedure attempts to determine whether the model results are realistic, relative to the true situation on the ground. It involves comparing model output with data on the ground, which had not been used in building the model.

For this study, validation of the modelling results of facilities for the national herd of cattle will involve, comparing the predicted level of veterinary practitioners that can be sustained by each location with the actual distribution of private veterinarians based on the results of an independent questionnaire survey of all professional veterinarians in Zimbabwe. The assumption here is that the existing distribution of private practitioners in Zimbabwe will show that practices are following simple common sense or logic in establishing practices where they are most likely to be viable. In line with suggestions by McCarl (1984), and Jakeman et al (1993), a measurement of degree of association, in this case, a simple correlation test will suffice. A strong correlation between the results predicted by the model, and the existing distribution of private practitioners as revealed in the independent questionnaire survey, would validate the model result.

Before carrying out the validation exercise, a number of factors need to be examined. First, the current modelling exercise is based entirely on large animal practice in Zimbabwe. The survey of private practitioners in Zimbabwe however suggests that the distribution of private practitioners is significantly influenced by contribution from small animal practices. Thus, the much sought after correlation needed for validation may not be achieved, and would not reflect the true situation on the ground. However, this set-back can be corrected for by transforming the model output.[12] This involves incorporating the small animal practice (SAP) contribution into the model result before validation. This is made possible by the survey data, which reveals certain factors as being responsible for the setting up of small animal

[12] Transformation recommended here is similar to the addition of dual rent to primal rent, before validation using the Land Rent Test (Hazell and Norton, 1986).

practices. Two factors in particular emerged, the human (or household) population of the catchment and the levels of urbanisation. Thus, different weights (coefficients) representing the level of urbanisation as well as the human population within the catchment of each practice location, will be used to transform the model outputs appropriately.

7.9.3 Transforming LP model output

An empirical method was specifically developed for this study, to determine the Small Animal Practice (SAP) contribution to the distribution of private practices in Zimbabwe. This is in recognition as discussed above, of the fact that the number of private practices sustained by any area, is a combination of the Small Animal Practice (SAP) and Large Animal (LA) contributions. Thus, actual level of private practitioners sustained can be represented as follows:

Actual PP = SAP Contribution + LA Contribution (LP Model prediction)

Meanwhile, as identified earlier, the viability of a SAP in any location is dependent on two factors:

1- Population Coefficient (human population of the area)

2- Urbanisation Coefficient (the contribution of urbanisation effect)

While the absolute population determines the potential demand for work for the private practices, urbanisation corrects for the attractiveness for setting up in urban areas, both in terms of the available wealth as well as the ease of practice (infrastructure). Crude weights for the above factors can therefore be developed, and combined to form the SAP contribution for the area. Thus:

SAP Contribution = Population Coeff. * Urbanisation Coeff.

Information from a survey of private practices in Harare is used here, to develop the SAP contributions for the whole country. For instance, it is known that the population of Harare of 1.2 million supports about eleven private practices (CSO Census, 1992, ZVA Survey Report, 1995). The average Harare private practice has 2.5 veterinarians, and small animal work contributes about two-thirds of their practice income. Thus, the Population Coefficient can be computed using the following steps:

1- There are about 18.3 veterinarians in SAP in Harare

i.e. {11(practices)*2.5 (vets per practice)*2/3(SA work)}

2- Each veterinary practitioner is supported by about 66 thousand people

i.e. {1.2 mill (people) /18.3 (practices)}

3- The Population Coefficient of a private practitioner is therefore about $1.51*10^{-5}$

i.e. (Population/66,000)

The Urbanisation Coefficient on the other hand, can be computed using the assumption that, a private practice is three times more likely to set up in an urban area than in a rural area, and twice as likely to set up in a semi-urban area than in a rural area. This relationship is based on the estimates reflecting the average income levels of populations residing in rural, semi-urban and urban areas in Zimbabwe (CSO Survey Report, 1991, 1995).[13],[14] Thus, if an area with predominantly urban population has a coefficient of 1, semi-urban populations will be 0.66 and rural populations 0.33. On the basis of the above, the status of the 63 clinical locations were determined and the above coefficients applied appropriately, depending on whether the prevailing population is predominantly urban, semi-urban or rural. As earlier suggested, the corrected predicted distribution of self-sustaining practitioners is then compared using a correlation analysis with the questionnaire survey results for its degree of association.

7.9.4 Results of validation exercise

Table 7.9a presents the results of the corrected LP model output, following transformation with the appropriate coefficients. After correction for SAP contribution, 39 of the 63 locations are predicted to be viable.

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[13] Household wealth is related to the availability of wage-related income. This is reported to be most available in Urban areas, less in semi-urban and least in rural areas.

[14] The population as well as the urbanisation status of the 63 locations was derived from the Central Statistical Office, Census (1992): Zimbabwe Preliminary Report., Harare, Zimbabwe.

Table 7.9a

Summary Result showing Computed Coefficients, LP Prediction and Corrected Prediction for Clinical Locations in Zimbabwe, under the Privatisation Scenario (0% Subsidy).

LOCATION	POPULATION '000	URBANISATION RATING	POPULATION COEFFICIENT	URBANISATION COEFFICIENT	SAP CONTRIBUTION	LP PREDICTION	CORRECTED PREDICTION
HARARE	1,200	3	18.2	1.0	18.2	3.2	21.4
BULAWAYO	621	3	9.4	1.0	9.4	0.9	10.3
MVUMA	70	1	1.1	0.3	0.4	5.1	5.5
KAROYI	260	2	3.9	0.7	2.6	1.9	4.5
MARONDERA	145	2	2.2	0.7	1.5	2.9	4.4
GWERU	212	2	3.2	0.7	2.1	1.8	3.9
RUSAPE	257	2	3.9	0.7	2.6	1.3	3.9
KADOMA	222	2	3.4	0.7	2.2	1.4	3.6
CHEGUTU	192	2	2.9	0.7	1.9	1.7	3.6
MUTARE	337	2	5.1	0.7	3.4	0.1	3.5
KWEKWE	250	2	3.8	0.7	2.5	0.9	3.4
MASVINGO	239	2	3.6	0.7	2.4	0.9	3.3
CHIVHU	147	1	2.2	0.3	0.7	2.1	2.8
MBERENGWA	183	1	2.8	0.3	0.9	1.9	2.8
CHIPINGE	337	1	5.1	0.3	1.7	1.1	2.8
MHANGURA	117	1	1.8	0.3	0.6	2.1	2.7
MACHEKE	10	1	0.2	0.3	0.1	2.6	2.7
CHINHOYI	43	2	0.7	0.7	0.4	2.2	2.6
BINDURA	119	2	1.8	0.7	1.2	1.4	2.6
PLUMTREE	157	2	2.4	0.7	1.6	1.0	2.6
INYATHI	36	1	0.5	0.3	0.2	2.4	2.6
SHURUGWI	87	2	1.3	0.7	0.9	1.4	2.3
BEATRICE	75	1	1.1	0.3	0.4	1.8	2.2
MWENEZI	101	1	1.5	0.3	0.5	1.6	2.1
GOKWE	403	1	6.1	0.3	2.0	0.0	2.0
RAFFINGORA	230	1	3.5	0.3	1.2	0.8	2.0
CHIREDZI	183	1	2.8	0.3	0.9	0.8	1.7
GWANDA	124	2	1.9	0.7	1.3	0.4	1.7
GUTU	195	1	3.0	0.3	1.0	0.6	1.6
WEDZA	70	1	1.1	0.3	0.4	1.2	1.6
MVURWI	10	1	0.2	0.3	0.1	1.5	1.6
ZVISHAVANE	93	2	1.4	0.7	0.9	0.6	1.5
MUTASA	164	1	2.5	0.3	0.8	0.6	1.4
ESIGODINI	63	1	1.0	0.3	0.3	1.1	1.4
HWANGE	131	2	2.0	0.7	1.3	0.0	1.3
BUHERA	204	1	3.1	0.3	1.0	0.0	1.0
GURUVE	136	1	2.1	0.3	0.7	0.3	1.0
ZAKA	191	1	2.9	0.3	1.0	0.0	1.0
MUBAIRA	10	1	0.2	0.3	0.1	0.9	1.0
NYANGA	128	1	1.9	0.3	0.6	0.3	0.9
CHIVI	157	1	2.4	0.3	0.8	0.1	0.9
CENTENARY	70	1	1.1	0.3	0.4	0.5	0.9
NYAMANDHLOVU	10	1	0.2	0.3	0.1	0.8	0.9
MOUNT DARWIN	164	1	2.5	0.3	0.8	0.0	0.8
BIKITA	154	1	2.3	0.3	0.8	0.0	0.8
MUREWA	152	1	2.3	0.3	0.8	0.0	0.8
CHIMANIMANI	111	1	1.7	0.3	0.6	0.2	0.8
WEST NICHOLSON	10	1	0.2	0.3	0.1	0.6	0.7
MUTOKO	123	1	1.9	0.3	0.6	0.0	0.6
NKAYI	113	1	1.7	0.3	0.6	0.0	0.6
MUDZI	109	1	1.7	0.3	0.6	0.0	0.6
BEITBRIDGE	80	1	1.2	0.3	0.4	0.1	0.5
LUPANE	94	1	1.4	0.3	0.5	0.0	0.5
KEZI	10	1	0.2	0.3	0.1	0.4	0.5
BINGA	87	1	1.3	0.3	0.4	0.0	0.4
RUSHINGA	75	1	1.1	0.3	0.4	0.0	0.4
FILABUSI	10	1	0.2	0.3	0.1	0.2	0.3
SANYATI	10	1	0.2	0.3	0.1	0.0	0.1
ZHOMBE	10	1	0.2	0.3	0.1	0.0	0.1
NEMBUDZIYA	10	1	0.2	0.3	0.1	0.0	0.1
LAZY Y RANCH	10	1	0.2	0.3	0.1	0.0	0.1
BUEHWA	10	1	0.2	0.3	0.1	0.0	0.1
NEDZIWA	10	1	0.2	0.3	0.1	0.0	0.1

Between them, the 39 locations were able to sustain 124 private practitioners. A total of 153 veterinarians responded to the questionnaire survey which in addition to other information, sought to find out the nature of their employment and their practice location. Of this number, 45 were private practitioners spread over 10 of the 63 locations under study. Using a correlation analysis, the distribution of these 45 private practitioners is then compared with the predicted distribution of professionals for the same practice locations.

Table 7.9b below provides a comparison between the Predicted (Corrected) and Actual (Survey) distribution of private practitioners over 10 of the 63 practice locations. Similarly, Table 7.9c provides the result of the correlation analysis between the Actual distribution of private practitioners in Zimbabwe and the Predicted distribution using the transformed LP Model results. The rather strong correlation produced by the analysis above validates the predictive strength of the LP model, and permits a number of observations and comments with regards to the prediction made by the LP model.

Table 7.9b
Comparison of the Existing Distribution of Private Practitioners with the Model Prediction (Corrected).

LOCATION	ACTUAL PRACTITIONERS	PREDICTED PRACTITIONERS
BEATRICE	1	2.2
CHIPINGE	1	2.8
GUTU	1	1.6
MARONDERA	2	4.4
MASVINGO	1	3.3
MUTARE	1	3.5
MVURWI	1	1.6
GWERU	2	3.9
BULAWAYO	10	10.3
HARARE	24	21.4

Table 7.9c
Result of Two-Tailed Correlation Analysis between Actual and Predicted Distribution of Private Practitioners in Zimbabwe.

	ACTUAL	PREDICTED (CORRECTED)
ACTUAL PRIVATE VETS	1.0000	.9930**
PREDICTED (CORRECTED)	.9930**	1.0000

**P = .000

1- The result suggests that, profit maximising private practitioners in Zimbabwe are already setting up in viable locations.

2- Harare and Bulawayo are more or less carrying an optimum level of private practitioners. The implication of this result is that, the establishment of further practices in these catchments, may put a strain on the viability of existing and new practices. This view is consistent with views expressed in the Zimbabwe Veterinary Association Survey Report (1995), where practitioners are beginning to have problems with their margins of profit in Harare and Bulawayo.

3- It is reasonable to suggest from these results that, other locations without private practices around the country, which have however been predicted by the model as being viable, are capable of sustaining the predicted numbers of practices. Thus, such areas constitute locations with potentials for private practices. Furthermore, the relative contribution of SAP and LAP to practice viability in these areas, is indicative of the type of practice to be established at these locations.

7.10 Conclusion

Three general null hypotheses were proposed at the beginning of this chapter, and on the basis of the results of the two LP modelling scenarios, it is possible to conclude that all three null hypotheses have been rejected. First, livestock resources in Zimbabwe have been shown to be capable of sustaining various levels of private practices, depending on the size, combination and location of the different livestock producer types within each catchment. Secondly, when professional veterinarians alone are allowed to practice, there will be quite clearly, a large difference in veterinary coverage between commercial and non-commercial livestock, hence the rejection of the second null hypothesis. However, the introduction of paraveterinarians is shown to greatly improve veterinary coverage especially for non-commercial livestock, a situation that negates the third null hypothesis.

In addition to the above general conclusions, more specific observations can be made on a number of aspects of the delivery system following the modelling of Scenario 1:

1- On the basis of the existing levels of veterinary expenditure and travel costs, this model suggests that, no non-commercial producer located farther than 25 kilometres from a clinic, will be served following privatisation, if only professional veterinarians are allowed to set up practice.

2- Practice (facility) viability is shown to be strongly related to the allocation of commercial livestock. Thus, commercial production can be said to be a pre-requisite for the viability of private practices and hence, the success of the privatisation policy. This conclusion appears to have a lot of support in the literature. However, the error inherent in this conclusion is exposed by the LP modelling of Scenario 2, the result of which is shown in the next point.

3- Both veterinary coverage and viability of private practices for non-commercial producers, whatever their location, are feasible and enhanced by the introduction of paraveterinarians.

A close examination of the two scenarios and the conclusions arrived at, reveals that three important characteristics of the delivery system are responsible for the veterinary coverage and viability witnessed in the study. They are as follows:

1- The cadre of the professionals, as represented by their income aspirations, acquires a great significance. The income aspirations of a private practice is determined by the running cost of the practice, and in part by the level of professionalism (education and hence technical ability) of the practitioner. This study suggests that high income aspirations reduce the chances of a practice being viable. Thus, it emerged that paraprofessional cadre with lower income aspirations, will succeed in areas with non-commercial producers with lower expenditure levels. It is expected that practice costs emanating from expensive equipment and buildings, will render a practice particularly unattractive to non-commercial producers. The appropriateness of professional veterinarians to serve non-commercial producers following privatisation, is called to question here. This is probably due to their high income aspirations, clearly emanating especially from expensive and probably excessive equipment. These items are probably inappropriate to the needs of the small, rural and non-commercial production units. A further factor which affects income aspiration is the level of professionalism (education) which translates to high cost of clinicians time and skills. Once again most of these skills are not required for providing services to smallholder producers. Hence, matching producer needs with appropriate provider costs and provider type is an important area of future research.

2- The importance of the location of a practice in relation to the population served, is once again highlighted by this study. Travel cost, including cost of travel time, is the main consideration by all practitioners involved in large animal work. This is the only cost that varies with location. This study shows that, given the same level of veterinary expenditure by producers, the profitability or otherwise of a practice serving any producer, is completely dependent on the distance of the herd from the practice. Thus, professional veterinarians can serve non-commercial producers profitably and be viable, provided the practice is located close enough to a large population of the clients. Hence, strategies such as setting up of practices at cattle markets or other locations where animals congregate would often guarantee viability (Anis, 1981). The successful use of private paraveterinary schemes for the control of epidemic diseases have been reported in the literature (Mariner, 1995, Mariner et al, 1994). There are various types of paraveterinary schemes, set-up mainly by non-governmental organisations (Hadrill, 1989, Grandin et al, 1991). Most schemes are usually part of other rural development projects with funding from overseas. The viability and long term sustainability of such schemes is however questionable, as a lot of them tend to be aid-dependent, and often fail following the withdrawal of the funding agents. However, in view of their potential in complementing professional veterinary practices, as revealed by this study, the integration of paraveterinary schemes into national health care delivery systems becomes pertinent, and constitutes an important area for future research (Mariner et al, 1995).

3- The nature of the services in terms of whether these are privately inclined or have free-rider properties has also emerged as being important. This factor determines whether or not there is a need for state intervention in the form of subsidy. Although a lot has been written on the economic nature of veterinary services following privatisation, very little exists in the form of empirical evidence or country case studies. An important preliminary observation from this study, is the potential role of subsidy in the viability of practices serving non-commercial producers in Zimbabwe. Because of the importance of this policy issue, an attempt will be made in the next chapter, to evaluate the economic and social impact of various policy scenarios involving withdrawal of subsidy in Zimbabwe.

CHAPTER 8

SOME ECONOMIC AND SOCIAL IMPLICATIONS OF POLICIES INVOLVING VETERINARY SUBSIDIES IN ZIMBABWE.

> *"No policy is intrinsically faulty but can be adjudged so only by those who, with the benefit of hindsight, can recall raised hopes which have been dashed and aspirations which never materialised".*
>
> (Isaac Odeyemi, 1997)

8.1 Introduction

Since the mid 1980s, the department of veterinary services of Zimbabwe has experienced progressive cut to its budgetary allocation, from the central government (Laidler et al, 1997). In real terms, this cut in 1996 alone, was estimated to be equivalent to about 30 percent of the total departmental budget. The persistence of such budgetary constraint is in part, responsible for considering the adoption of the privatisation policy. One of the major components of the privatisation policy, is the removal of subsidy on a number of services hitherto provided either free or partly subsidised by the government. It is hoped that this will reduce the financial burden on the department. However, the choice of services, or level of subsidy to apply, is a problematic one for policy planners and administrators alike. This is due in part, to the fact that, in addition to economic implications, subsidy removal has social implications as well. For instance, it is feared that, a removal of subsidy would lead to a general decrease in consumption (uptake) of veterinary services, with its consequences for the health status of the national herd. Such a decrease in consumption is particularly expected to be more pronounced amongst the poorer sector of the population, in this case the non-commercial smallholder producers.

Another aspect of the privatisation policy and the withdrawal of subsidy, is its effect on veterinary employment. It is expected under the privatisation policy that, veterinarians will be encouraged to go into private practice. Consequently, as had happened in other countries in the region, the government is expected to "down-size". This in effect, implies the closure of some clinical facilities and the retrenchment of some personnel. Already, in line with the privatisation policy, and partly due to budgetary constraints, the Zimbabwean government had placed an embargo since the early 1990s, on the recruitment of fresh veterinary graduates. The consequence of both of the above actions is veterinary unemployment, unless the private sector can absorb the "surplus" veterinarians. Discussion with some members of the veterinary faculty suggest that, between 1994 and 1996, less than 25 percent of new veterinary graduates, from the countries veterinary faculty in Harare, were employed within the country. The majority of new graduates are currently unemployed, and a few of them seek employment in neighbouring countries of Swaziland, Botswana, South Africa and Namibia.

The paraveterinarians constitute the lower cadre of professionals in the delivery system, and will be the most affected by any retrenchment and "down-sizing" activity by the government. As it were, the privatisation models being considered by most African countries, including Zimbabwe, do not include a role for private paraveterinarians. As was shown in the previous chapter, it is possible under various privatisation scenarios to support both professional veterinarians and paraveterinarians. Models are developed to allow the prediction of activities in real life situations. Hence, the LP model developed in the last chapter will be used here to predict the economic impact of a number of scenarios of subsidy levels in Zimbabwe. Similarly, the health, equity and employment consequences of subsidy withdrawal in privatisation will be investigated. The importance of being able to assess and compare alternative health care policies as well as their social significance cannot be over emphasised (Wagstaff, 1994). It is hoped that, this study will facilitate decisions on whether or not to provide subsidies in Zimbabwe, and suggest what level of subsidy is appropriate where possible.

8.2 The economic value of veterinary subsidies

There are different types of direct and indirect subsidies in operation in the animal health delivery systems of most countries. While indirect subsidies are mostly associated with providing the institutional framework for service delivery, direct subsidies are often a product of the political framework or ideology of a country. Examples of indirect subsidies include funding for research, disease surveillance, administrative support, and in some cases diagnostic services. More direct subsidies can be found where privately inclined services as well as those services with "free rider" or externalities are funded either partially or completely.

In Zimbabwe, full costs are currently recovered from livestock producers for meat inspection, laboratory tests, drug and input purchases, as well as privately inclined treatments and surgical operations. However, livestock producers only pay Z$3 per head, or 25 percent, of the cost of dipping their livestock against ecto-parasites (Dip Tank Survey, 1995). Meanwhile, vaccination against epidemic diseases, in particular Foot and Mouth Disease (FMD) in non-commercial communal cattle, attracts full subsidy in order to facilitate beef export by commercial producers (Laidler et al, 1997). It is estimated that, dipping subsidy to the 5 million cattle population alone, constitutes about 30 percent of the total operational budget of the department of veterinary services of Zimbabwe. This amounts to about Z$45 million annually. Furthermore, vaccinating all 3.4 million non-commercial cattle in Zimbabwe for FMD, at the rate of Z$5 per head, is estimated to cost the department about Z$17 million annually.

It emerges from the above that, total removal of subsidy to livestock producers for dipping and FMD, will result in savings for the government of about Z$62 million.[1] Where partial subsidy is the considered option, the proportion of the above that is saved, depends on the level of subsidy retained. On the other hand, the cost of withdrawal of subsidy varies between the two production systems. Of the Z$62

[1] This figure assumes a 100 percent coverage. However, this is seldom the case.

million, which is the total value of the subsidy, the amount due to commercial producers is only Z$14.4 million. Meanwhile, subsidy to smallscale non-commercial producers amounts to about Z$47.6 million. It is thus obvious that, a total removal of subsidy will have a greater economic impact on smallscale non-commercial producers than it will on the wealthier commercial producers. While it is important to be able to compute the financial savings to the government following a policy of withdrawal of subsidy, it is equally as important, to be able to determine how this will affect veterinary coverage, equity and veterinary employment.

From the above discussions, a number of hypothesis can be put forward with regards to economic and social impact of removal of subsidy:

1- There are no health implications to withdrawal of subsidy.

2- Withdrawal of subsidy has no economic impact on either the producers or the government.

3- There are no social implications to withdrawal of subsidy.

It is immediately clear from the information provided earlier that, the government's budget will benefit from a withdrawal of subsidy, by amounts equivalent to the level of subsidy discontinued. However, it is less clear how producers will react, or whether this will have economic or health implications, as reflected by their levels of veterinary coverage (uptake). These factors are important and certainly need to be carefully weighed before any policy decision is taken. Similarly, the social implications of the policy, such as issues relating to equity of coverage for the various categories of livestock producers, as well as veterinary employment opportunities for the various cadre of professionals, will equally benefit from our modelling exercise.

8.3 Assumptions and approaches for modelling subsidy withdrawal

The allocation of the 5 million cattle population of Zimbabwe, to the 63 clinical facilities will be modelled using the LP model developed in the last chapter, under different policy scenarios. As was the case in the previous chapter, populations that are covered are those whose facilities have Practice Viability Index (PVI) of 1 or greater than 1. Furthermore, the three general assumptions with regard to the privatisation scenario also hold, that is:

1- That both producer types benefit from the same level of dipping subsidy.

2- Only non-commercial producers benefit from FMD subsidy.

3- That the latent demand (maximum WTP) value is invoked.

Another important assumption, this time specific to the issue of withdrawal of subsidies, is the likely reaction of producers to consumption of services. Following the withdrawal of subsidies, livestock producers are able to behave in one of three possible ways:

1- Producers increase their level of consumption of veterinary services, as the level of subsidy decreases.

2- Producers continue to consume the same level of services irrespective of the level of subsidy removed.

3- Producers' veterinary expenditure and hence consumption of services decrease, proportional to the level of subsidy removed.

Of the three reactions above, the more logical line of action to be taken by livestock producers is the third option, and this is adopted for the modelling exercises here. This is based on the fact that there is a pre-determined maximum amount that producers are willing to spend on veterinary services (WTP). Since producers have a limit to their resources, it is thus assumed that, once this level is reached, further reduction of subsidy by the government would lead to a decrease in the level of services consumed. At the point where all subsidies are removed, then the producers will be consuming services worth the equivalence of their maximum WTP value. The approach adopted for modelling the impact of withdrawal of subsidy is to gradually increase or decrease the level of subsidy provided to producers and run the LP model for the 63 locations. Subsidy is varied from 0 percent to 100 percent, at an incremental level of 25 percent.[2] The impact of the policy (subsidy) changes can then be measured, using the number of self financed practices (professionals) sustained as a marker for determining covered populations. The assumptions above can then be applied in this modelling exercise in the following way:

1- Each population (activity level) is assigned a starting expenditure (practice income) level.[3]

2- The expenditure level is then progressively decreased or increased according to the monetary equivalent of the desired percentage subsidy being altered.

8.4 Modelled scenarios of subsidy

Although different types of subsidies exist in Zimbabwe, only subsidies for FMD and dipping have been selected for modelling due to their importance as policy issues in Zimbabwe. The two subsidies differ in a number of ways. For while Dip subsidy applies to all categories of livestock (commercial and non-commercial), FMD subsidy only applies to non-commercial livestock. Secondly, the percentage and value of the two subsidies vary. While 100 percent subsidy valued at Z$5 is provided for FMD, Dip subsidy is only 75 percent, but valued at Z$9. Three sets of scenarios involving FMD and Dip subsidies were analysed:[4]

1- Stepwise increase in FMD subsidy alone.

2- Stepwise increase in Dip subsidy alone.

3- Stepwise increase in FMD and then Dip subsidies together.

While five scenarios (0%, 25%, 50%, 75% and 100%), are modelled for each of FMD and Dip analysis, the combined FMD-Dip analysis results in a total of nine scenarios modelled as follows:

- Scenario 1 (0% FMD + 0% Dip)
- Scenario 2 (25% FMD + 0% Dip)

[2] Note that while a 25% increment in dipping subsidy represents Z$3, it represents only Z$1.25 in FMD subsidy.

[3] The expenditure levels are related to the coefficients derived for the LP models in the previous chapter.

[4] A hypothetical zero percent subsidy level is calculated and used as the starting point for the various scenarios studied, hence, increase rather than decrease in subsidy is simulated.

- Scenario 3 (50% FMD + 0% Dip)
- Scenario 4 (75% FMD + 0% Dip)
- Scenario 5 (100% FMD + 0% Dip)
- Scenario 6 (100% FMD + 25% Dip)
- Scenario 7 (100% FMD + 50% Dip)
- Scenario 8 (100% FMD + 75% Dip)
- Scenario 9 (100% FMD + 100% Dip)

8.5 Results

The summaries of the three sets of subsidy analysis are presented below, in Tables 8.1, 8.2 and 8.3. These represent the LP modelling of the stepwise increase of subsidies for FMD alone, Dip alone and combined FMD and Dip respectively. In all three tables, columns 2, 3 and 4 provide the picture of changes to veterinary coverage for the commercial, non-commercial and total livestock of Zimbabwe, as subsidy levels increase.

Columns 5 and 6 on the other hand, shows the number of self-financing professional veterinarians (Provets) and paraprofessional (Paravets) that will be produced or sustained as subsidy levels increase, under the same three sets of scenarios.

The salient points of the results contained in these tables and charts can be summarised as follows:

1- When all subsidies are removed, 80 percent of commercial, and 0 percent of non-commercial livestock will be covered by self-financing private practices. At the national level, this translates to only 25 percent veterinary coverage for the national cattle herd (Table 8.3).

2- Similarly, the removal of all subsidies will produce about 45 self-financing private professional veterinarians, but not a single self-sustaining paraveterinarian.

3- When subsidy levels of FMD is raised from 0 to 100 percent, the proportion of non-commercial livestock, and the national herd covered, rises to 86 percent and 84 percent respectively. However, FMD subsidy at 100 percent level, has no effect whatsoever, on veterinary coverage for commercial livestock.

Table 8.1

Summary of LP Modelling of Scenarios involving Withdrawal of FMD Subsidy.

SCENARIO	COMMERCIAL LIVESTOCK(%)	NON-COM. LIVESTOCK(%)	TOTAL LIVESTOCK(%)	PRO-VETS. SUSTAINED	PARA-VETS. SUSTAINED
0% FMD	80.2	0	25.3	44.7	0
25% FMD	80.2	0	25.3	44.7	0
50% FMD	80.2	61.2	67.2	44.7	28.8
75% FMD	80.2	78.2	78.8	44.7	52.0
100% FMD	80.2	86.1	84.2	44.7	73.6

Table 8.2

Summary of LP Modelling of Scenarios involving Withdrawal of Dip Subsidy.

SCENARIO	COMMERCIAL LIVESTOCK (%)	NON-COM. LIVESTOCK(%)	TOTAL LIVESTOCK (%)	PRO-VETS. SUSTAINED	PARA-VETS. SUSTAINED
0% DIP	80.2	0	25.3	44.7	0
25% DIP	85.1	73.4	77.1	51.4	40.4
50% DIP	86.6	90.2	89.1	56.4	91.2
75% DIP	89.2	95.2	93.3	62.2	141.0
100% DIP	90.5	95.8	94.1	67.5	171.6

Table 8.3

Summary of LP Modelling of Withdrawal of FMD and Dip Subsidies.

SCENARIO	COMMERCIAL LIVESTOCK (%)	NON-COM. LIVESTOCK (%)	TOTAL LIVESTOCK (%)	PRO-VETS. SUSTAINED	PARA-VETS. SUSTAINED
0% FMD + 0% DIP	80.2	0	25.3	44.7	0
25% FMD + 0% DIP	80.2	0	25.3	44.7	0
50% FMD + 0% DIP	80.2	61.2	67.2	44.7	28.8
75% FMD + 0% DIP	80.2	78.2	78.8	44.7	52.0
100% FMD + 0% DIP	80.2	86.1	84.2	44.7	73.6
100% FMD + 25% DIP	85.1	94.5	91.5	51.4	125.1
100% FMD + 50% DIP	86.6	95.8	92.9	56.4	171.6
100% FMD + 75% DIP	90.5	97.2	95.1	63.6	219.2
100% FMD + 100% DIP	90.5	97.2	95.1	67.5	249.5

A visual picture of the changes described in the tables, is provided by the charts in Figures 8.1a to 8.4.

FIGURE 8.1a.
NON-COMMERCIAL LIVESTOCK COVERED BY DIFFERENT SUBSIDY SCHEMES

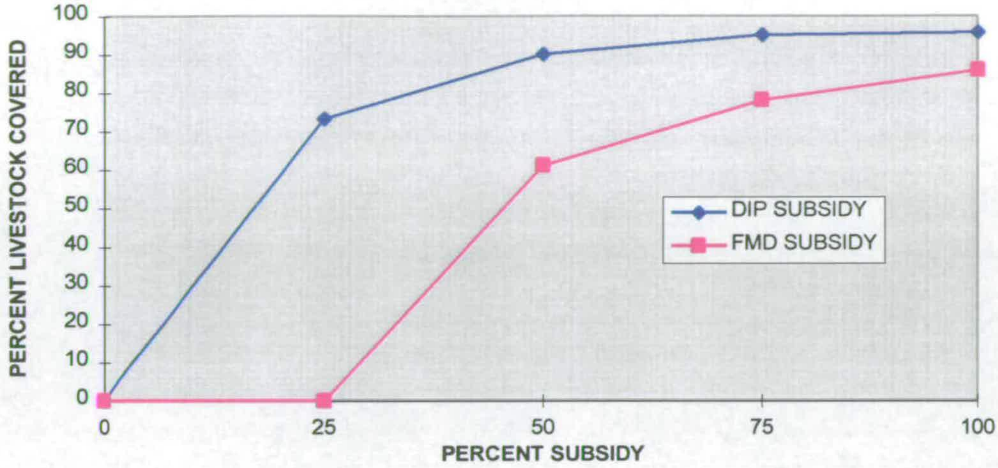
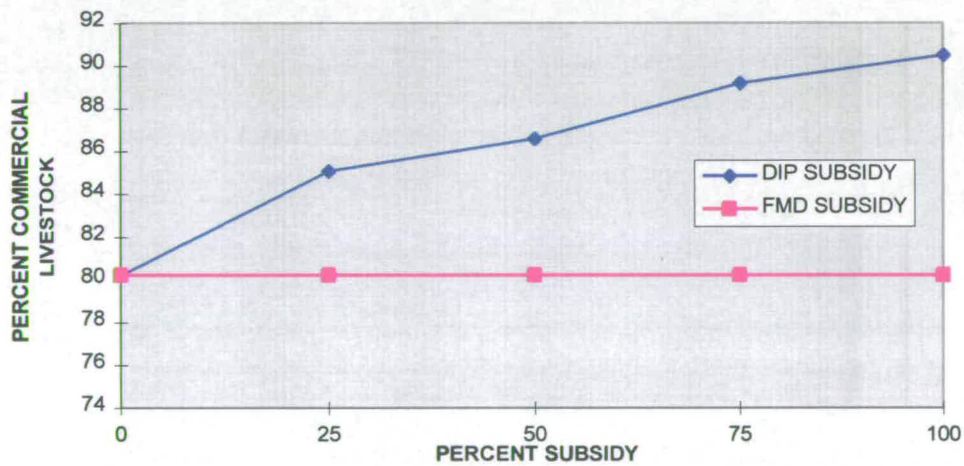


FIGURE 8.1b.
COMMERCIAL LIVESTOCK COVERED BY DIFFERENT SUBSIDY SCHEMES



Note:

Due to the difference in monetary value between FMD and Dip subsidies (Z$5 and Z$12 respectively), changes in percentage subsidy result in different levels of veterinary coverage for non-commercial cattle. From all indications however, withdrawal of the same monetary value of FMD or Dip subsidy, should depress veterinary coverage by the same amount.

FIGURE 8.2a.
EFFECT OF CHANGES IN DIPPING SUBSIDIES ON VETERINARY COVERAGE

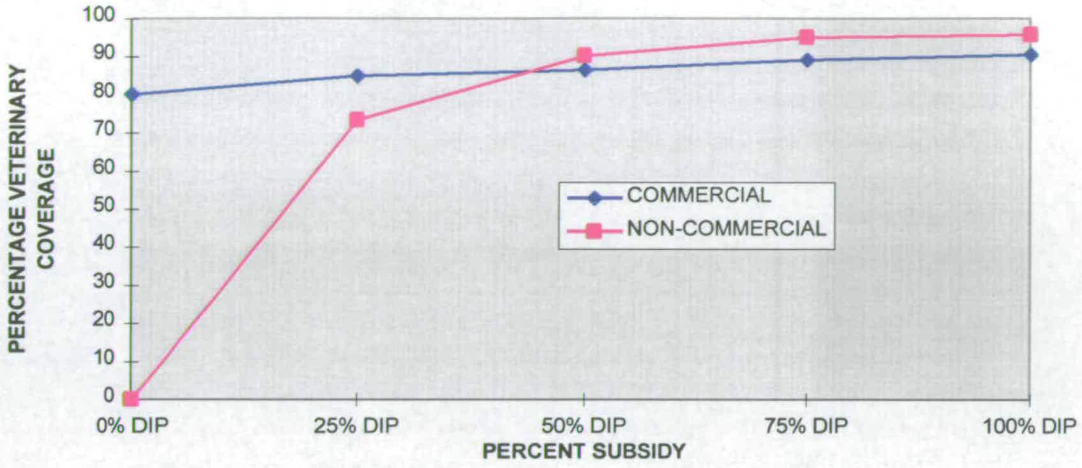


FIGURE 8.2b.
EFFECT OF CHANGES IN FMD SUBSIDY ON VETERINARY COVERAGE

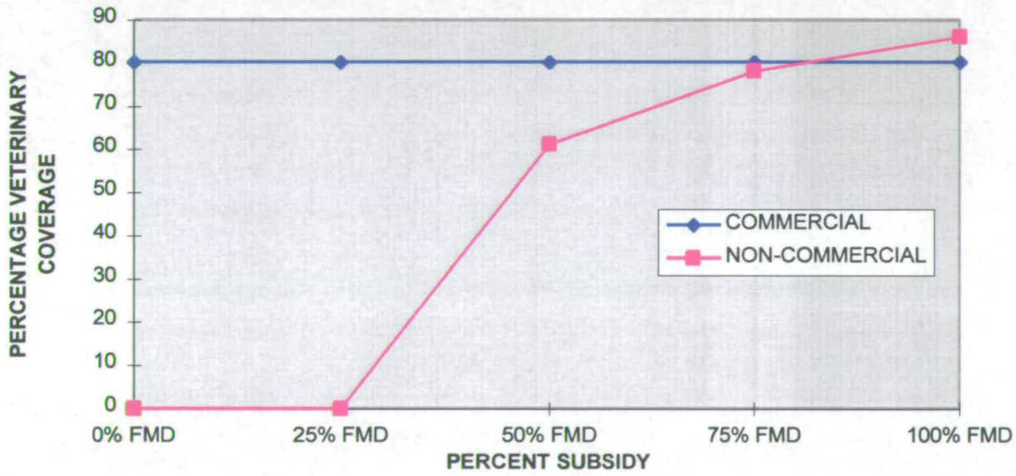


FIGURE 8.3a.
EFFECT OF COMBINED FMD AND DIP SUBSIDIES ON NUMBER OF SELF-FINANCING VETERINARY PROFESSIONALS

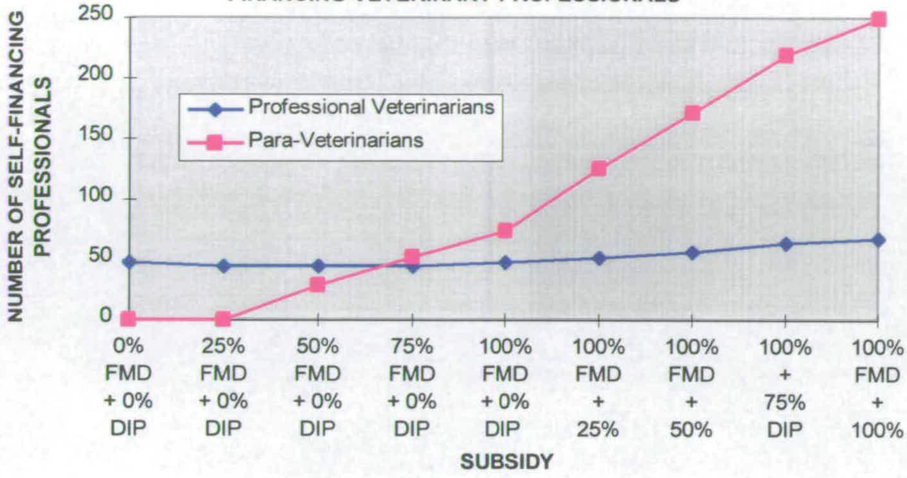


FIGURE 8.3b.
EFFECT OF COMBINED FMD AND DIP SUBSIDIES ON VETERINARY COVERAGE

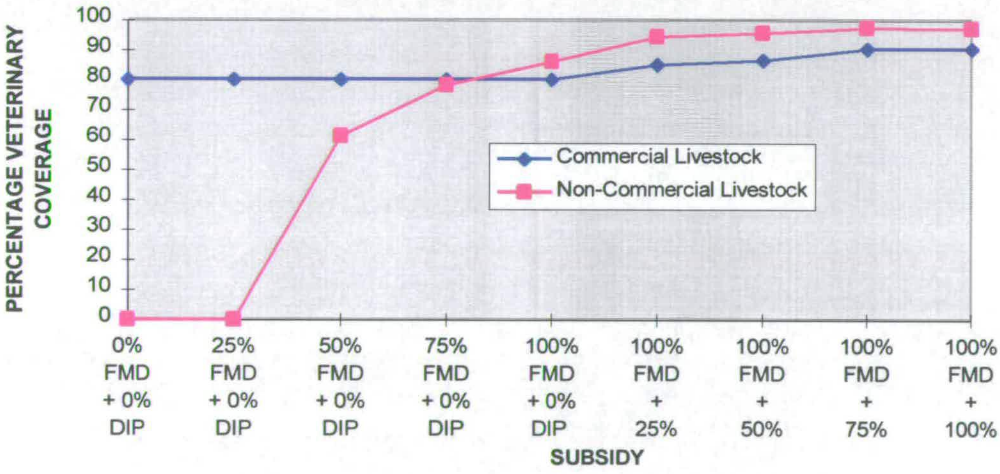
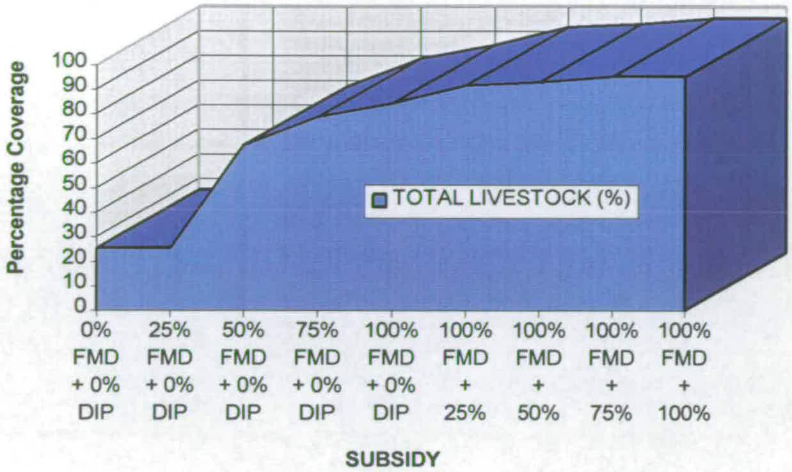


FIGURE 8.4.
National Herd Covered following changes in FMD and Dip Subsidy.



4- Increase in Dip subsidy to 100 percent level, raises veterinary coverage for commercial cattle from 80 percent to 91 percent. At that level of Dip subsidy, veterinary coverage for non-commercial cattle rises to about 95 percent.

5- While increase from 0 percent to 100 percent, in Dip subsidy raises the population of self-financing professional veterinarians from 45 to 65, the population of self-financing paraveterinarians increases from 0 to 172.

6- The provision of full subsidy for both FMD and Dip (100 percent), raises veterinary coverage for the national herd of cattle from 25 percent to 95 percent. This figure breaks down into 91 percent for commercial cattle and 97 percent for non-commercial cattle.

7- Meanwhile, full subsidy will produce about 68 self-financing professional veterinarians, and 250 paraprofessionals.

Figures 8.5, 8.6 and 8.7, are maps displaying the administrative districts where commercial and non-commercial livestock are covered at scenarios of subsidy levels of 0 percent for all subsidies, and full subsidy (100 percent for both FMD and Dip combined) respectively. In each of the maps, the numbers of self-financing professionals are displayed under the same subsidy scenarios as above.

Figure 8.5 Commercial Cattle Veterinary Coverage at Zero Subsidy

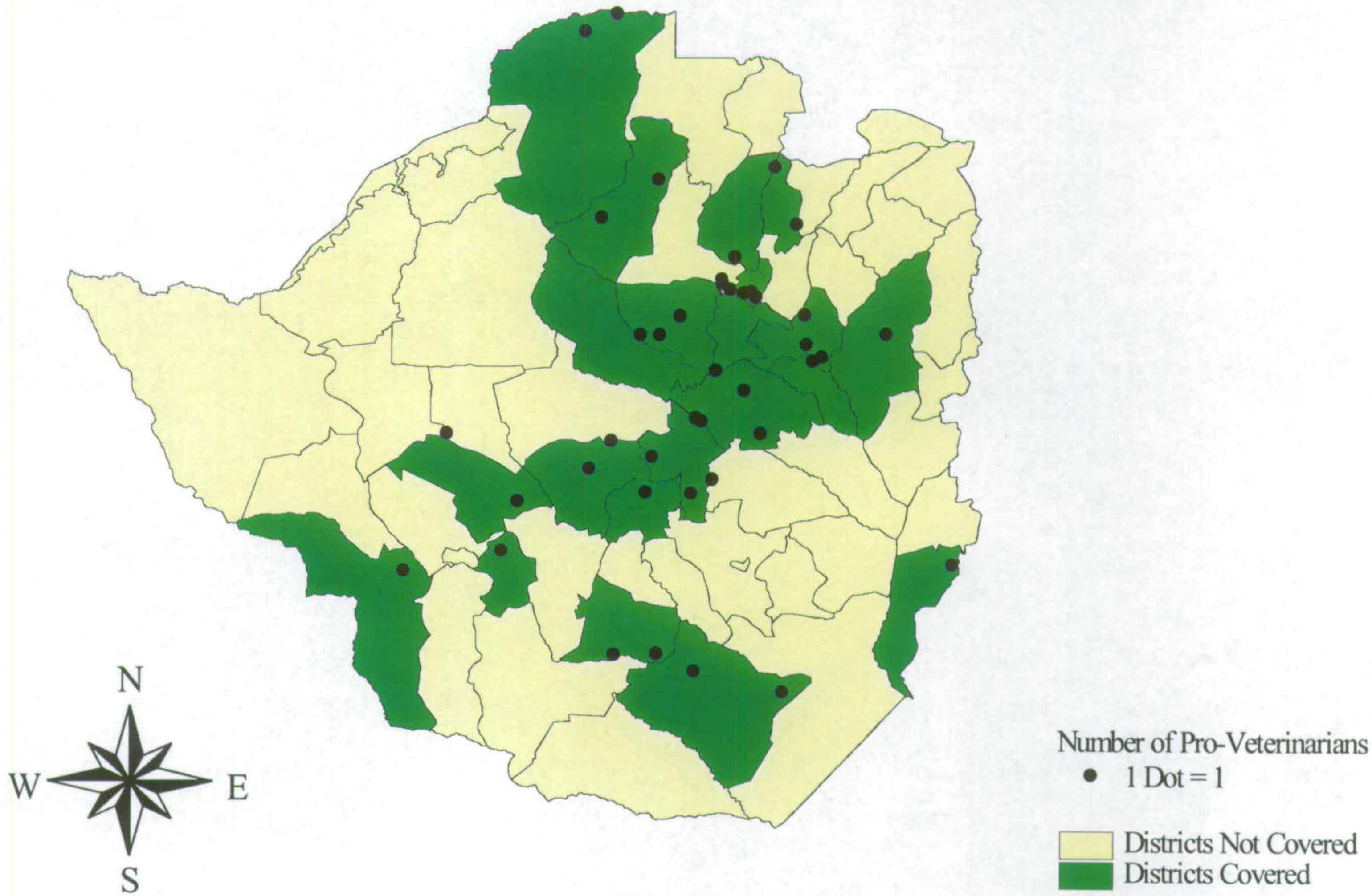


Figure 8.6 Commercial Cattle Veterinary Coverage at Full Subsidy

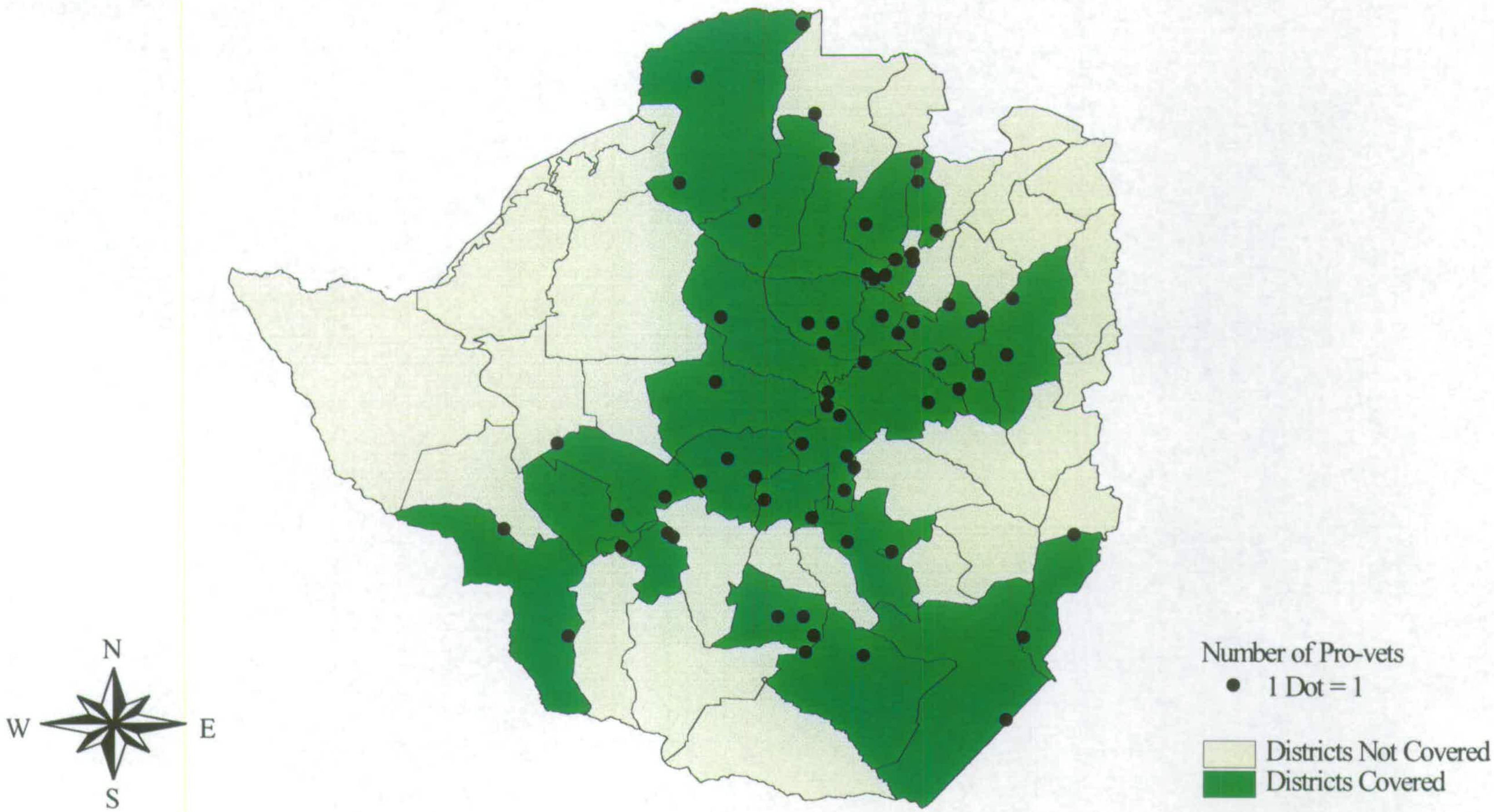
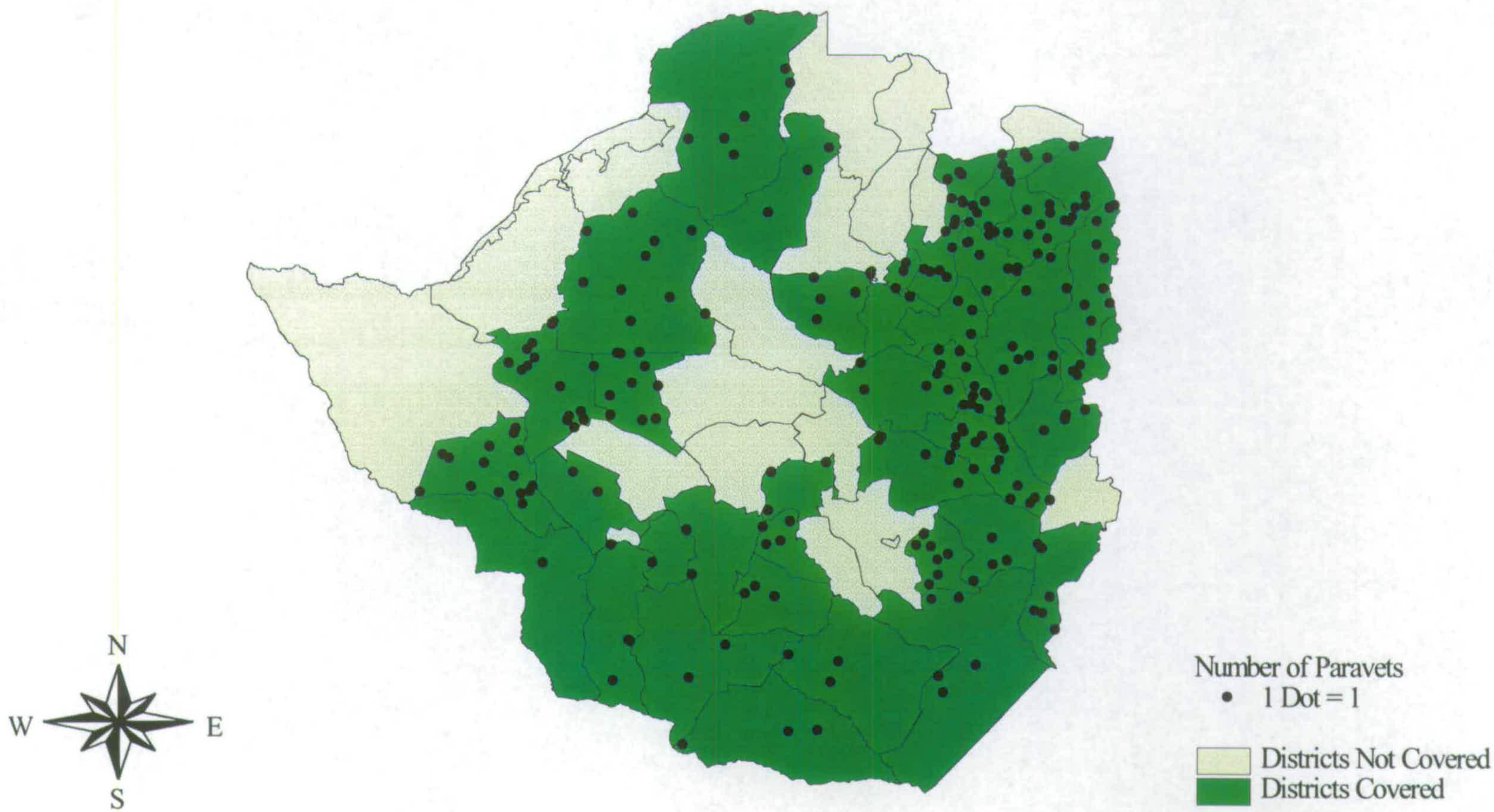


Figure 8.7 Non-Commercial Cattle Veterinary Coverage at Full Subsidy



There was no need to display a map for veterinary coverage for non-commercial cattle at 0 percent subsidy, as there are no cattle covered by self-financing practices at that level of subsidy. In comparing the maps in Figures 8.5 and 8.6, it becomes clear that, full subsidy only has moderate impact on veterinary coverage for commercial livestock. On the other hand, both forms of subsidy have a great impact on veterinary coverage for non-commercial cattle, as well as on the numbers of paraprofessionals sustained (Figure 8.7). As mentioned earlier, no self-sustaining paraveterinarian existed under the 0 percent subsidy scenario, and hence no cattle were covered.

8.6 Discussion and conclusion

Policy reforms such as privatisation, will quite clearly benefit from techniques which can identify their effects as well as estimate their cost and benefits, both before and after the reform has been implemented (Lutz and Minasinghe, 1994). The withdrawal of subsidies is central to the ongoing discussions on the implementation of the policy of privatisation of animal health services in most countries in Africa, including Zimbabwe. The benefits of an analysis such as is represented by this study, is immeasurable to the delivery of animal health services in Zimbabwe and other countries to which the methodology and results can be extrapolated. In interpreting the results of this modelling exercise, the following assumptions still hold, that:

1- Government withdraws from the direct provision of all clinical services, and that subsidy, where provided, is in the form of payment to private practitioners for contracted out services.

2- Areas predicted as covered by self-financing practices, can be privatised under the scenarios modelled. Thus, uncovered areas represent populations that have to be served through direct government delivery, or provision of additional subsidy to encourage self-financing private practitioners to cover the populations.

The three null hypothesis on which the analysis of this chapter is based have all been rejected, based on the results of the analysis conducted. Withdrawal of subsidy quite clearly has health implications in decreased veterinary coverage, marginalisation and inequity between livestock producer groups as well as employment opportunities for different cadres of health care providers. However, one major conclusion is clear from all the results of this study, and that is that, under privatisation, for any form of veterinary coverage for the non-commercial producers to occur, there must be one form of subsidy or the other. The type and value of the subsidy is however dependent on the Governments policy objective and the target set for veterinary coverage. To what extent the burden created by subsidy on government finances is reduced, depends on the imagination, resourcefulness and efficiency of the government administrators.

In suggesting contracting-out as a means of providing subsidy, a number of problems become immediately apparent (Csaba and Fenn, 1997). First, it is clear that when there are just a few practitioners to pick from, such a policy can create monopolistic markets, just like the government services it is replacing, with its consequences on the market. For instance, how much choice is available to consumers and how can quality be guaranteed. Secondly, questions immediately arise as to what services should be subsidised, who should determine the contract fees and how should the fee be set? It has been shown in other countries where contracting-out of services has been practised, that the lobbying capacity of each practice tends to influence contract fee levels (HIVSS, 1997a and 1997b). The literature on alternative methods of contracting-out of veterinary services is scanty. The Local Veterinary Inspector (LVI) Scheme for Tuberculosis testing, and the Highland and Island Veterinary Services Scheme (HIVSS), both in the United Kingdom, represent examples of contracting-out schemes. Both schemes employ different fee setting techniques, but these have seldom been questioned as to the competitiveness of the fees. The literature from human health and industry suggest that, there are two general fee setting arrangements, also referred to as cost-based reimbursements (CBR). The rates may be determined either on the basis of the cost of the service as declared by the practitioner, or on the basis of on-going charges for similar services, where a parallel private sector exists for similar charges (Danzon, 1982). There are advantages and disadvantages to either system. Fees based on cost of service incurred could quite easily be inflated and vary widely between practitioners. When tightened too much, it could be a disincentive for practitioners to provide the services (Joskow, 1983). On the other hand, it is possible for on-going rates, where such is adopted, to be too high, and may be reflecting the practice's other administrative costs, rather than the cost of the particular service requested. Thus, each subsidy case must be viewed on its own merits.

With a tool such as this LP model, it becomes relatively easy to see the economic and health trade-offs that will occur following various types and levels of subsidy. However, in deciding what services to subsidise, it is also necessary to understand the character of each service under consideration. For instance, dipping is inherently exclusively a private good, the cost of which the producers should be, ideally, fully responsible. In Zimbabwe in particular, the fact that the dipping consumes over a quarter of the departmental operational budget, further puts pressure on the administrators to look at the possibility of subsidy withdrawal. Already, fees equivalent to a quarter of costs have been introduced, with further withdrawals on the policy agenda. Government's reluctance to completely withdraw subsidies for dipping, stems from two points. Firstly, the process of dipping provides the veterinary department with its unprecedented opportunity of disease monitoring, which occurs on the twenty two or more occasions that each herd is presented to the government operated dip tanks for dipping (Dip Tank Survey, 1995). Furthermore, the dip tanks constitute treatment points as well as one of the few physical evidences of government presence in the communal areas. Closing down of dip tanks are therefore likely to result in political fallout in addition to any disease consequences.

However, a closer examination of dipping policy highlights two areas of possible intervention. Dip subsidy is granted to both commercial and non-commercial cattle, even when a questionnaire survey of producers shows that over 90 percent of the commercial producers are willing to pay for the service (Chapter 4). Furthermore, the result of the LP modelling shows that, even when all Dip subsidy has been withdrawn, over 80 percent of commercial livestock are still covered. These two results quite clearly call to question the continuous subsidy to commercial producers estimated (by this study) to cost the Zimbabwean government about Z$14 million annually. A strategy of selective subsidy to non-commercial producers must be a considered option, when discussing subsidy as a policy issue in Zimbabwe.

Continuous subsidy for FMD saddles the government with a burden of about Z$17 million, if all non-commercial cattle are vaccinated annually. At present, subsidy for FMD vaccination is clearly inevitable, as non-commercial producers are unlikely to agree to any full or part-payment for the service. Since FMD vaccination is being enforced by the government, mainly as a means of fulfilling the conditions for guaranteeing beef export by commercial producers, it may be more appropriate for the government to pay for FMD control, through taxes or levies on commercial beef exports. The difficulty with this funding strategy is that, in the past, revenue generated through similar taxes such as slaughter taxes and trade cattle levies, often goes directly into the government treasury, and is not channelled back into the departmental budget. But these are administrative details that have to be worked out between the various ministries, and have nothing to do with efficiency of animal health resource allocation. If the purpose for which the levy is being imposed is made clear to treasury officials, it should be easier to make a case for re-investing the money appropriately.

In conclusion, it is important to emphasise that providing the appropriate level of subsidy is often a fine balancing act between the benefits derived by producers from subsidies and the financial cost to governments or other funding agencies. That level of subsidy which confers an "economic optima" (maximum welfare) on the whole economic system appears to be the most appropriate level to adopt (James, 1997).[5]

[5] Social Cost Benefit considerations implied.

CHAPTER 9

GENERAL SUMMARY AND CONCLUSION

9.1 Introduction

The principal working hypothesis of this study was that, ***"the adoption of privatisation oriented policy reforms, in the delivery of animal health care services in Africa, will have adverse economic and social impact on the various stakeholders".*** This hypothesis was informed by the wide-spread lack of impact and failures with the current privatisation, and by the restructuring policy reforms noticed in the animal health care delivery systems all over Africa and other developing economies. Particularly apparent with most health care delivery systems are some developmental problems which have persisted despite over a decade of reform-led initiatives. These include the followings:

- Under-resourcing of animal health care services
- Poor management of scarce resources
- In-appropriate allocation of health care resources
- Economic loses due to inadequate health care delivery
- Growing unemployment amongst health care professionals

The results of this study, and the conclusions made, are in agreement with aspects of the principal hypothesis, in that ***privatisation and other related health care policy reforms are going to have a great economic and social impact in Zimbabwe.*** However, whether or not the impacts are adverse in nature, will depend on the efficiency of implementation of the policy initiatives. Evidence from the literature suggests that the policy appears to be implemented in the absence of appropriate enabling institutions, hence the problems being encountered. In particular, two major factors appear to limit the ability of planners and administrators to adequately implement privatisation oriented policies:

- A lack of understanding of the policies by the stakeholders, which have led in most cases to mis-conceptions, unfavourable attitudes and the resultant poor uptake.
- The absence of a framework for evaluating delivery systems, especially under the prevailing diverse socio-economic environments in Africa. This was particularly responsible for the problems with the planning and implementation of health care policy interventions resulting in in-appropriate interventions and mis-allocation of resources.

In view of the above problems, this study is aimed at creating a better understanding of the dynamics of animal health care systems under the privatisation policy. The main output of the study is therefore a framework that will permit accurate evaluation of the delivery system such that the various components of the above research hypothesis can be tested. In general, five principles were identified as essential to understanding the privatisation policy in the delivery of animal health services:

- Privatisation is not an "all-or-none" process
- Privatisation is a dynamic process
- Privatisation is a desirable process
- Level of privatisation is predictable
- Privatisation is an evolutionary and not a revolutionary process

These principles above highlight some of the policy issues that the principal research hypothesis attempts to address. Consequently, a five-step Precision Service Delivery (PSD) framework was developed to specifically address, in a quantifiable and logical way, the various dimensions to the problem of evaluating health care delivery systems. Viz.:

- Qualify- characterise the stakeholders in the delivery system
- Quantify- establish the size of the elements comprising the system
- Aggregate- geo-spatial characteristic of the elements
- Analyse- policy related decision analysis using derived indices

- Disseminate- develop or implement appropriate policy interventions

Table 9.1 provides a summary of the results of tests made at validating the PSD framework involving several primary and secondary research hypothesis. Field data from Zimbabwe was used in the analysis.

Table 9.1.
Summary of Hypothesis and Conclusions

Objective	Hypothesis	Conclusion
• Principal Hypothesis	• ***The adoption of privatisation policy reforms, in the delivery of animal health services in Africa, will have adverse economic and social impact on the various stakeholders.*** (Chapter 1)	• **True & False: Privatisation and other related health care policy reforms will have a great economic and social impact in Zimbabwe but this need not be adverse** (Chapter 9)
• Principal Hypothesis	• *There is scope for accurately evaluating the efficiency of delivery of animal health services under the divers socio-economic systems, as well as geographical locations in Africa and other developing economies* (Chapter 3)	• **True**: The Precision Service Delivery (PSD) Framework provides the scope for evaluating various dimensions of health care delivery systems (Chapter 3)
• PSD Step 1 (Qualify)	• *The uptake of a privately delivered animal health service will be influenced or indeed determined by the prevailing livestock production systems in the country or region (Chapter 4)*	• **False**: Production systems per se, are not responsible for uptake, but rather, individual producer characteristics (Chapter 4).
• PSD Step 1 (Qualify)	• *There are no distinguishable (useful) dimensions to the putative production characteristics (Chapter 4)*	• **False**: Fourteen useable dimensions of the putative production characteristics were identified for Zimbabwe (Chapter 4).
• PSD Step 1 (Qualify)	• *The different livestock production systems cannot be classified using the identified dimensions of the putative variables (Chapter 4)*	• **False**: The different production systems were accurately discriminated by the dimensions derived from the putative variables (Chapter 4)
• PSD Step 1 (Qualify)	• *The demand for veterinary services by the various production systems cannot be predicted on the basis of some identified unique dimensions (Chapter 4).*	• **True**: The dimensions which are influential in characterising the production systems are not significant in predicting either indicators of uptake (Chapter 4)
• PSD Step 2 (Quantify)	• *Demand for veterinary services will decrease with privatisation (Chapter 5).*	**False**: Privatisation will increase rather than decrease the uptake of selected animal health services in Zimbabwe (Chapter 5).
• PSD Step 2 (Quantify)	• *The economic value of the latent demand for privatised services can be evaluated (Chapter 5).*	• **True:** Quantifying the latent demand for privatised animal health services in Zimbabwe has been attempted in this study using the WTP (CV) technique (Chapter 5).

Table 9.1 Continued.

Objective	Hypothesis	Conclusion
• PSD Step 3 (Geospatial Aggregation)	• *There is scope for improving the spatial distribution of existing or planned facilities of delivery of animal health services in Zimbabwe, thereby bringing about greater efficiency and equity of access as well as ensuring viability and sustainability (Chapter 6)*	• **True**: Location-Allocation modelling technique provides a means of testing locational efficiency and equity of services delivery systems (Chapter 6).
• PSD Step 3 (Geospatial Aggregation)	• *The spatial distribution of existing veterinary facilities in Zimbabwe is inefficient with regards to access (Chapter 6).*	• **True**: The current location of veterinary facilities in Zimbabwe inherently inefficient and can be improved upon (Chapter 6).
• PSD Step 3 (Geospatial Aggregation)	• *The spatial distribution of existing veterinary facilities in Zimbabwe is equitable (Chapter 6).*	• **True**: Non-commercial producers, as well as low-income householders have less access to veterinary services in Zimbabwe than their counterparts (Chapter 6)
• PSD Step 4 (Decision Analysis)	• *The livestock resources in Zimbabwe cannot sustain economically viable (self-financing) private veterinary practices in existing veterinary facilities (Chapter 7).*	• **True & False**: livestock resources in Zimbabwe is able (in some cases) to sustain various levels of private professional veterinary practices, depending on the size, combination and location of the different livestock producer types (Chapter 7).
• PSD Step 4 (Decision Analysis)	• *Privatisation will result in no difference in access to veterinary services, between the different livestock producer groups in the country (Chapter 7).*	• **False**: When professional veterinarians alone are allowed to practice, there will be a large difference in veterinary coverage between commercial and non-commercial livestock (Chapter 7).
• PSD Step 4 (Decision Analysis)	• *The introduction of an independent cadre of paraprofessionals into the delivery system will not bring about any significant change to veterinary coverage (Chapter 7).*	• **False**: The introduction of paraveterinarians is shown to greatly improve veterinary coverage especially for non-commercial livestock (Chapter 7).
• PSD Step 5 (Implement/ Disseminate)	• *There are no health implications to the withdrawal of subsidy (Chapter 8).*	• **False**: Withdrawal of subsidy will result in decreased veterinary coverage to the national herd (Chapter 8).
• PSD Step 5 (Implement/ Disseminate)	• *Withdrawal of subsidy has no economic impact on either the producers or the government (Chapter 8).*	• **False**: Withdrawal of subsidy results in financial loss to non-commercial producers as well as private practitioners (Chapter 8).
PSD Step 5 (Implement/ Disseminate)	• *There are no social implications to withdrawal of subsidy (Chapter 8).*	• **False**: Withdrawal of subsidy will result in inequity of access between livestock producer groups Non-commercial producers in particular will be marginalised. Furthermore, employment opportunities for different cadres of health care providers will decrease with subsidy withdrawal (Chapter 8).

9.2 General conclusions and recommendations

1- Veterinary uptake: a factor of intrinsic farmer characteristics.

- The level of veterinary services consumed by any particular producer is influenced by his attitudes and other intrinsic characteristics rather than just the economic factors that define the production system the producer belongs to.
- Thus, in understanding the dynamics of privatisation, individual producer profiles are as important a predictor of veterinary uptake as is the type of production systems they belong to.

2- Increased demand: a consequence of privatisation.

- In Zimbabwe, privatisation would result in an increase, rather than a decrease, in uptake of animal health care services. Selective consumption of services may however result, with producers consuming a different bundle of goods (services) from those hitherto on offer by public service health care providers.
- Viability may thus depend on the service providers strategically targeting the specific health care demands of the producer groups within their practice area.

3- Inequity in access: the poor fare worse in Zimbabwe.

- Existing infrastructure for animal health care delivery is sub-optimally located and therefore inherently inefficient. In particular, rural non-commercial producers have less access than their commercial producer counterparts. Similarly, the poorer segment of the urban population also have less access to small animal practice than the wealthier households.
- To ensure greater efficiency and equity of access, there is a need to re-organise existing veterinary infrastructure, including the relocation of a number of health care facilities prior to, or as part of, any government planned privatisation policy initiatives.

4- Veterinary professionalism: the case for paraveterinarians.

- Privatisation appears to have very little impact on veterinary coverage for commercial producers in Zimbabwe. Furthermore, the number of private professional veterinarians is not greatly affected by privatisation. However, without professionals with a lower income aspiration, such as the paraveterinarians or fresh veterinary graduates, veterinary services to rural non-commercial producers will be virtually non-existent following privatisation.

- This thus makes a case for the inclusion of a paraveterinary cadre of professionals when developing a privatisation scheme for the delivery of animal health services in Zimbabwe. The dynamics of setting up and funding these schemes demands that these be done on an area-by-area basis. Furthermore, the determination of the appropriate manning levels for any area or country, should influence national policies on manpower development, such as the number of veterinary schools to set up as well as the numbers and types of veterinary professionals to produce.

5- Viability and sustainability: meeting the specific needs of the farmers.

- The services demanded by individual livestock producers are different. These services differ both between and within production systems, and are likely to change with time.
- Consequently, the success of any private practice is dependent on its ability to respond to the specific, and sometimes, changing user's needs. More specifically, the viability of the majority of private practices (professional or paraprofessional), that would provide health care services for non-commercial livestock especially in rural areas, would depend on the government contracting out a number of services (including some with public good character) to these practices.

6- Neo-privatisation theory: a paradigm shift.

- There needs to be a paradigm shift in the economic theory behind the privatisation policy in the animal health care delivery system in Africa. The original theory, the utility theory (free market approach), which predicts who should pay for what services based on the utility derived, may not be valid with respect to animal health care delivery services in Zimbabwe. The theory pre-supposes that all services with a "private good" character should be provided by the private sector and attract full payment from the beneficiaries. On the other hand, services with "public good" character, or with externalities, should continue to be funded and provided by the government. Adhering to such a policy is shown by this study to result in a lack of veterinary coverage for the majority of non-commercial livestock in Zimbabwe, given the existing income aspirations of the various cadres of professionals.

- The "neo-privatisation" theory suggests that cost-effective delivery and optimum veterinary coverage may involve selective subsidy of some services, including those with "private good" character, for some producers in some locations, under certain circumstances.

9.3 Limitations and areas for future research

- Data limitations

The range and size of analysis undertaken in this study under scores the importance of availability of quality data. In countries, regions or areas where quality data is not readily available or cannot be accessed, this framework may be unworkable, despite its usefulness. In particular, in a number of African countries, the framework is likely to suffer from poor quality secondary data relating to livestock population and distribution. Equally, various aspects requiring surveys for primary data, are likely to suffer from sampling inadequacy, especially in very large countries or regions where sample data needs to be extrapolated to the whole country. Furthermore, the efficiency of conducting and analysing questionnaire surveys, such as enumerator bias and questionnaire designs, will greatly affect the outcome of the PSD framework. However, the PSD framework is robust enough to provide consistently accurate results, provided simple survey rules are observed, and area-specific studies are conducted and used.

- Software development

With the framework developed in this study, the capacity now exists to determine in a more precise manner, the resource needs for research and disease control initiatives aimed at ensuring greater efficiency as well as equity for different livestock producer groups in Africa. Despite all its potentials however, the above framework in its present form, constitutes isolated techniques for specialists in different disciplines. A desirable objective therefore, would be to take these advancements a final step forwards by integrating the various geo-spatial and econometric techniques into a single computer software. A simple "user-friendly" menu system will allow the choice of analysis from the wide range on offer. Through its ability to bring about a more rational policy decision making process, the outputs of such a project, will directly and positively impact upon the ability of the various organs of delivery of livestock production and health services to provide a more efficient and equitable service. However, the methodology will undoubtedly benefit from further improvement and modification making it more efficient and appropriate for different study areas and objectives.

9.4 Extrapolating research output

This study constitutes a major breakthrough in on-going efforts to address the problems afflicting the delivery of animal health services in Africa, and other developing economies. Indeed, veterinary and human health care delivery in developed countries could potentially benefit from various aspects of the study too. While direct extrapolation to other country situations, of the specific results and conclusions of this study, may be inappropriate, the framework and methodologies upon which the PSD framework is built has universal application, with potential benefit to all health care delivery systems. The inclusion of spatial analysis and decision analysis, to traditional cross-sectional population studies, has now introduced the opportunity for area-specific targeting of populations with appropriate health care interventions. Furthermore, the linking of econometric and social science methodologies broadens the scope of aspects of the health care delivery systems that can be evaluated. It is probably appropriate to conclude that the capabilities of the PSD framework can only be limited, not by the robustness of the technique, but by the imagination and dexterity (or the lack of either) of the technician applying the methodology.

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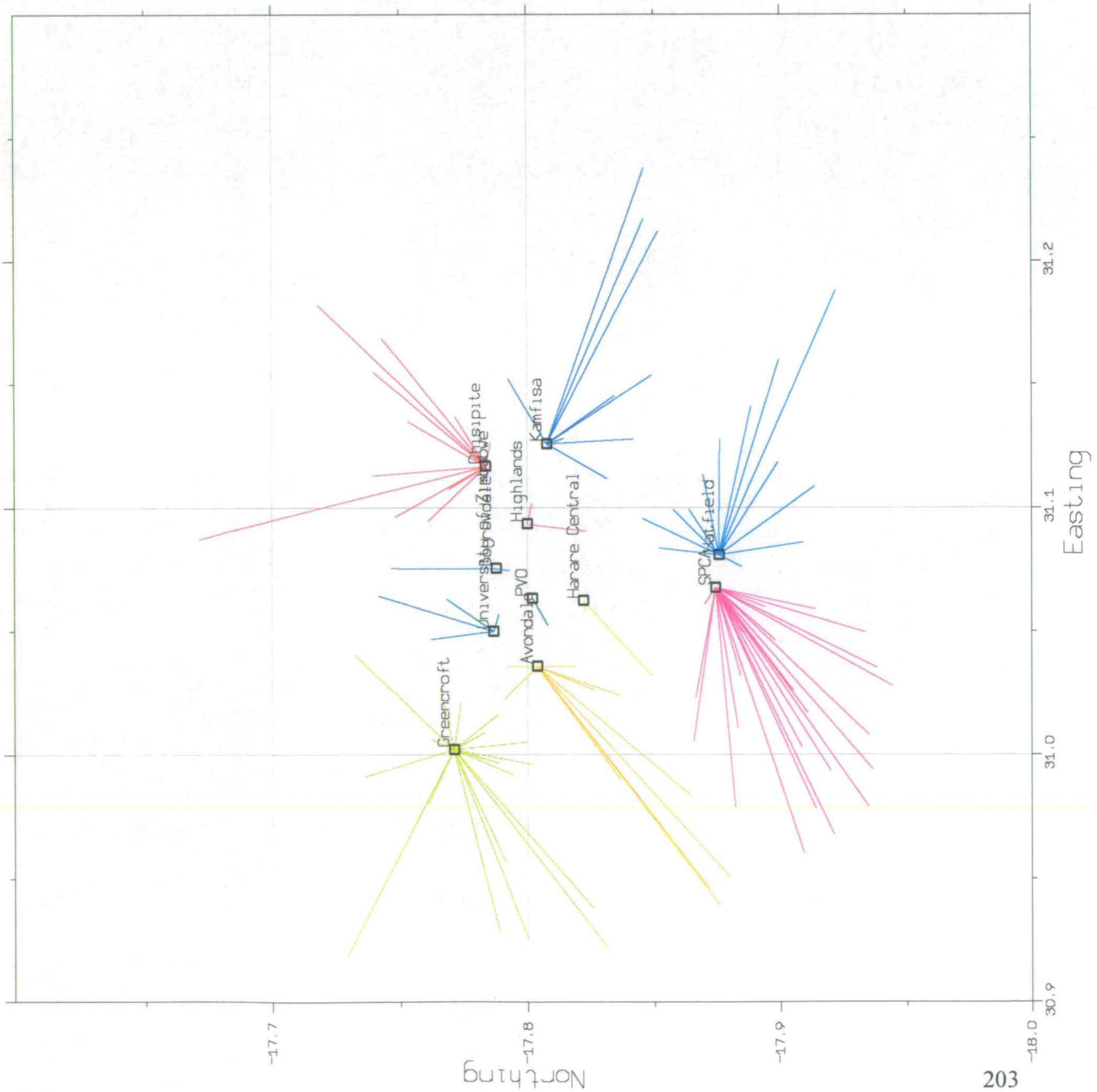
APPENDICES

APPENDIX 1: LOCATION-ALLOCATION MODELLING

1.1 Sample GRAFLOC Output and Control Files

1.2 GRAFLOC Monogram

GRAFLOC Spider-Graph:
Showing allocation of Harare population to existing Veterinary Clinics



GRAFLOC CONTROL.DAT FILE

```
1
1 y n y n 2 1 y empty.dat 30.9 31.3 0.1 -18.0 -17.6 0.1
FIGURE_1._Allocation_To_Exisiting_Harare_Practices_
humpop2.txt 4 2 3 4

11
1     31.1167 -17.7838   f   1   0   0   Chisipite
2     31.0632 -17.802    f   1   0   0   PVO
3     31.1258 -17.8077   f   1   0   0   Kamfisa
4     31.0808 -17.8758   f   1   0   0   Hatfield
5     31.0675 -17.8745   f   1   0   0   SPCA
6     31.0623 -17.8222   f   1   0   0   Harare_Central
7     31.0357 -17.804    f   1   0   0   Avondale
8     31.0022 -17.7713   f   1   0   0   Greencroft
9     31.05   -17.7868   f   1   0   0   University_of_Zimbabwe
10    31.0753 -17.7878   f   1   0   0   Borrowdale
11    31.0933 -17.8      f   1   0   0   Highlands
```

```
number of overall runs
print do_plot plot_markers plot_graticule plot_rings start_mkcol start_mksty plot_pop
annot_file wcx1 wcx2 wcdx wcy1 wcy2 wcdy
plot_title
town_file col_tot col_x col_y col_pop
nfacils
  ifacil[j] xs[j] ys[j] facil_fixed[j] flsp[j] dxs[j] dys[j] facil_name[j]
```

<u>**GRAFLOC PROFILE.DAT FILE**</u>

4 Distance rings (km):

	5.00	12.00	25.00	1000000.00

Run 1: FIGURE 1. Allocation To Existing Harare Practices

Chisipite	2.70	0.92	0.71	0.00
	2.70	3.62	4.33	4.33
PVO	0.38	0.00	0.00	0.00
	0.38	0.38	0.38	0.38
Kamfisa	2.96	4.23	2.50	0.00
	2.96	7.19	9.69	9.69
Hatfield	3.40	5.45	1.96	0.00
	3.40	8.85	10.80	10.80
SPCA	9.27	26.25	4.97	0.00
	9.27	35.53	40.49	40.49
Harare Central	2.76	0.00	0.00	0.00
	2.76	2.76	2.76	2.76
Avondale	2.51	5.65	4.32	0.00
	2.51	8.16	12.48	12.48
Greencroft	4.79	10.81	0.00	0.00
	4.79	15.60	15.60	15.60
University of Zimbabwe	0.84	0.28	0.00	0.00
	0.84	1.12	1.12	1.12
Borrowdale	1.10	0.00	0.00	0.00
	1.10	1.10	1.10	1.10
Highlands	1.24	0.00	0.00	0.00
	1.24	1.24	1.24	1.24
System	31.95	53.60	14.45	0.00
	31.95	85.55	100.00	100.00

COST.DAT FILE

Mean & Maximum Travel Cost units = km
Run 1: FIGURE 1. Allocation To Existing Harare Practices

	Mean	Maximum
Chisipite	5.61	13.00
PVO	1.39	1.39
Kamfisa	8.70	13.18
Hatfield	7.45	12.98
SPCA	7.65	12.52
Harare Central	1.11	4.48
Avondale	8.03	13.36
Greencroft	6.87	11.21
University of Zimbabwe	2.82	5.23
Borrowdale	1.58	4.55
Highlands	1.51	2.62
System	7.17	13.36

Total aggregate travel cost (km): 2115710.25 for pop. of 295186

APPENDIX 1.2

GRAFLOC MONOGRAM

(Written by D. Finnegan, Department of Geography, University of Edinburgh)

1 Using GRAFLOC

1.1 Overview

GRAFLOC is a location-allocation modelling program designed to run under Microsoft Windows 3.1. Later versions of Microsoft Windows (95, 98, NT4) also allow Windows 3.1 programs to run, so GRAFLOC runs under these systems as well. Although GRAFLOC has features which can deal with some aspects of locations in a network, it only optimizes locations in Euclidean space.

1.2 Input files

1. Grafloc.exe - the executable program (Windows 3.1)
2. Params.dat - model parameter input file
3. Control.dat - model run control file plus supply locations
4. A file containing demand locations
5. A file containing annotation text (can be empty)

1.3 Output files

1. Stats.dat - summary model run output
2. Costs.dat - mean and maximum travel cost model output
3. Profile.dat - percentage of total catchment for each supply point within given travel cost radii
4. Progress.dat - model run progress (iteration number plus current overall mean travel cost)
5. Goblin.tmp - graphical output file used for re-drawing operations

1.4 Format of input files

Values in input files must be 'whitespace' delimited i.e. separated by one or more spaces, tabs, or carriage-returns. (In Excel, this would be tab-delimited text file output option). Comma-delimited format will NOT work. Consequently, 'String' types referred to in the tables below cannot have embedded spaces. Where spaces are required for output, use underscore ('_') instead.

Value names enclosed in square brackets ([value name]) indicates that the presence of the value name is optional. Value names preceded by an asterisk (*value name) indicates that there may be more than one entry for this value name.

1.4.1 Params.dat

Value name	Value type	Description
Tolerance value	Float	to control termination of model run iterations - in units specified by output units (below)
'b'-value	Float	Distance decay value (for overlapping catchments only)
'v'-value	Float	For maximum use/maximum benefit objectives only
Objective	Character	't' = minimize travel; 'u' = maximize use; 'b' = maximize benefit Usually 't'
Catchments	Character	'n' = nearest neighbour; 'o' = overlapping catchments (us. 'n')
Space	Character	'e' = Euclidean; 'n' = network; 'm' = Manhattan grid (us. 'e')
Manhattan grid angle	Float	Clockwise rotation in degrees of Manhattan grid (us. 0.0)
Xmin	Float	No longer used
Xmax	Float	No longer used
Dx	Float	No longer used
Ymin	Float	No longer used
Ymax	Float	No longer used
Dy	Float	No longer used
Input coordinate units	String	'km' or 'metres' or 'miles' or 'degrees' (or 'seconds' or 'minutes') All coordinates must be in one of these units. Seconds/minutes only used with input network file, below.
Rings	Integer	Number of distance ring specifiers to follow (may be 0)
*[Ring limit]	Float	Distance ring specifier defines an outer limit from each supply point, for break-down of catchments
X Rings		
[Input ring units]	String	'km' or 'metres' or 'miles' or 'degrees' (or 'seconds' or 'minutes'
[Input network file]	String	If Space = 'n' (network) filename of cost matrix file
[Input network units]	String	If Space = network, units of cost matrix - as for other units
Output units	String	'km' or 'metres' or 'miles' or 'degrees' (or 'seconds' or 'minutes'
Allocate	Character	'y' = do allocation; 'n' = load in allocation table from a file
[allocation file]	String	If Allocate = 'n', filename of allocation table

1.4.1.1 Sample params.dat file format

```
1.5    1.5    0.5    t      n      e
0.0    99.0   99.0   9.0    99.0   99.0   9.0
degrees
3 10 35 50 km
km
y
```

1.4.2 Control.dat

Value name	Value type	Description
Runs	Integer	Total number of model runs (us. 1)
Print flag	Integer	1 = send plot to default printer, 0 = display plot on screen
Graphics	Character	'y' = output plot; 'n' = create output files only (us. 'y')
Markers	Character	'y' = draw catchments using points; 'n' = draw catchments using lines ('spider plot')
Graticule	Character	'y' = draw graticule grid; 'n' = do not draw graticule grid (us. 'y')
Rings	Character	'y' = draw distance rings; 'n' = do not draw distance rings (us. 'n')
Start marker colour	Integer	If Markers = 'y', colour index for initial marker (us. 2)
Start marker style	Integer	If Markers = 'y', marker index for initial marker (us. 1)
Demand	Character	'y' = draw points showing demand; 'n' = don't
Annotation file	String	Filename of annotation text file
Xmin	Float	Leftmost limit of plot in units of 'input coordinate units'
Xmax	Float	Rightmost limit of plot in units of 'input coordinate units'
Dx	Float	Horizontal plot interval in units of 'input coordinate units'
Ymin	Float	Lower limit of plot in units of 'input coordinate units'
Ymax	Float	Upper limit of plot in units of 'input coordinate units'
Dy	Float	Vertical plot interval in units of 'input coordinate units'
Title	String	Title of given model run, shown on plot and in output files. Note that underscores ('_') will be printed as spaces (' ').
Demand file	String	Filename of demand file (may include full path)
Demand file columns	Integer	Total number of columns in demand file
Demand file x column	Integer	Column number containing x-values
Demand file y column	Integer	Column number containing y-values
Demand file demand column	Integer	Column number containing demand-values
Supplies	Integer	Number of supply points to follow
*Supply point index	Integer	Unique identifier for this supply point
*Supply point x	Float	X coordinate of this supply point in input coordinate units
*Supply point y	Float	Y coordinate of this supply point in input coordinate units
*Supply fixed	Character	'f' = fixed supply point; 'm' = movable supply point
*Supply attractiveness	Float	Attractiveness weighting of this supply (for overlapping catchments only)
*Supply text dx	Float	X coord. offset for supply label text in input coordinate units
*Supply text dy	Float	Y coord. offset for supply label text in input coordinate units
*Supply name	String	Name of this supply point, used as label text
X Supplies		
X Runs		

1.4.2.1 Sample control.dat file format

```
2
0 n n y n 2 1 y
annot.dat
25.0 35.0 1.0 -25.0 -15.0 1.0
Title:_model_run_one
demand.dat 5 2 3 4
1
1 31.1 -17.6 m 1 0 0 demand_start_point1
0 n n y n 2 1 y
annot.dat
25.0 35.0 1.0 -25.0 -15.0 1.0
Title:_model_run_two
demand.dat 5 2 3 5
1
1 32.3 -17.9 m 1 0 0 demand_start_point2
```

1.4.3 Demand locations file

This file must be a 'whitespace' delimited text file i.e. with values separated by one or more spaces, tabs, or carriage returns. (In Excel, this would be the tab-delimited text file output option). Comma-delimited format will NOT work.

Values must be in column form, and have three columns which can be used as follows

1. The x-coordinate of the demand point
2. The y-coordinate of the demand point
3. The demand measure for this point

The coordinates must be compatible with the units recognized by Grafloc i.e. degrees, km, metres or miles. Otherwise a conversion to one of these units will be necessary.

1.4.3.1 Sample demand locations file format

Rocklands	29.58534	-17.1878	1291	532
Lazy_Y	29.53997	-17.3058	1429	765
Rhino_Ranch	29.29622	-18.1037	837	201
Mambo	29.38231	-18.184	600	323
Lodstar	29.3925	-18.238	706	357
Witpens	29.47653	-18.1647	1162	512

The x and y coordinates are in the second and third columns respectively, with two sets of demand values in columns four and five.

1.4.4 Annotation text file

This file contains text which is displayed at specified coordinates. These coordinates are NOT used in the modelling process. Their only purpose is to annotate the displayed plot, for example to show major cities.

Value name	**Value type**	**Description**
x-coordinate	Float	X coordinate of this annotation point in input coordinate units
y-coordinate	Float	Y coordinate of this annotation point in input coordinate units
Dx	Float	X coord. offset for annotation text in input coordinate units
Dy	Float	Y coord. offset for annotation text in input coordinate units
Size	Float	Annotation text height in millimetres
Text	String	Annotation text

1.4.4.1 Sample annotation text file format

```
328.58  675.56  0.0  0.0  3.0 Eastern_General
350.31  674.11  0.0  0.0  3.0 Roodlands
366.59  678.25  0.0  0.0  3.0 Belhaven_Dunbar
355.14  679.34  0.0  0.0  3.0 East_Fortune_Drem
335.27  672.04  0.0  0.0  3.0 Edenhall
```

APPENDIX 2: LINEAR PROGRAMMING MODEL

2.1 Linear Programming input data (Allocation of cattle to clinics)

2.2 Karoyi Privatisation Scenario 1 at Full Provet Income Aspiration

2.3 Karoyi Privatisation Scenario 1 at 80% Provet Income Aspiration

2.4 Disk Copy of Linear Programming for Animal Health Services in Zimbabwe

APPENDIX 2.1

Population of Cattle Within Four Distance Rings of
Veterinary Practice Locations in Zimbabwe (LP Input Data)

	Commercial Cattle				Smallscale Cattle			
	0-25 Km	25-35 Km	35-45 Km	>45 Km	0-25 Km	25-35 Km	35-45 Km	>45 Km
KADOMA	15505	22783	0	0	2744	343	1029	0
KAROYI	39395	0	11391	0	1372	21609	26411	44933
SANYATI	0	0	0	0	26411	5488	4116	15435
GWERU	30694	0	19619	0	0	0	0	0
KWEKWE	12183	12183	0	0	1372	4116	0	0
GOKWE	0	0	0	0	31213	27783	15092	54881
ZHOMBE	0	0	0	0	42532	25382	4116	0
SHURUGWI	13765	0	27688	0	10976	25382	3087	1715
MBERENGWA	17562	0	0	47306	4802	10633	8232	5831
NEMBUDZIYA	0	0	0	0	38759	29498	0	16807
BULAWAYO	14398	10284	0	0	2401	1715	2058	0
LUPANE	0	0	0	1740	12348	15435	18179	148521
HWANGE	1108	0	0	0	0	0	0	1029
INYATHI	26580	0	7436	45566	3773	1372	0	6174
NYAMANDHLOVU	20410	0	0	0	6174	3773	4802	11662
NKAYI	0	0	0	0	28126	43561	22295	38759
GWANDA	0	11075	0	0	13720	11319	4459	3087
PLUMTREE	3323	0	20093	10442	0	0	4116	10976
FILABUSI	5696	0	0	0	16121	5145	2744	0
ESIGODINI	30377	0	0	0	9947	12348	4116	1715
KEZI	10442	0	0	0	11662	15778	8575	24010
BEITBRIDGE	0	0	2848	0	6860	4116	3430	21952
WEST NICHOLSON	0	0	0	22625	9947	11319	15435	34300
LAZY Y RANCH	0	0	0	0	9604	8232	343	3087
BINGA	0	0	0	0	0	0	0	1372
HARARE	26264	47939	15347	0	7203	18865	1029	4802
MARONDERA	43825	37022	0	0	17836	22295	5488	0
MUREWA	0	0	0	0	79577	52137	4802	0
CHIVHU	25631	791	35440	0	23324	24696	20580	0
BEATRICE	38130	0	12657	0	18522	7889	4459	0
MUTOKO	791	0	0	0	50765	40131	30184	35672
MUDZI	0	0	0	0	10633	9947	8918	16464
MACHEKE	54109	15663	0	0	15778	14063	19551	13377
WEDZA	17562	15663	0	0	45620	46992	22295	1715
BINDURA	13765	24049	0	0	4459	6517	0	0
CENTENARY	12499	2057	0	0	5145	0	0	0
MOUNT DARWIN	158	0	0	0	13720	1715	0	0
GURUVE	9018	0	0	0	9947	1715	0	0
MVURWI	24049	17878	0	0	1029	0	0	0
RUSHINGA	0	0	0	0	7203	4802	5488	686
CHINHOYI	17878	11708	33383	0	0	7889	29498	5831
CHEGUTU	16454	30219	0	0	0	20580	21266	4802
MHANGURA	21359	36548	0	0	343	5145	2744	0
RAFFINGORA	21043	0	0	0	0	0	0	0
MUBAIRA	0	0	27688	0	58654	9261	21266	4802
ZVISHAVANE	0	17562	0	0	18179	13720	5488	0
MVUMA	113282	5063	18986	0	1372	1715	1029	2744
BUEHWA	0	0	0	0	27097	7546	18522	5145
MASVINGO	2848	21359	0	0	2058	3087	5488	0
GUTU	0	18511	0	0	61055	30184	5831	0
CHIREDZI	20410	0	0	0	3430	3087	16807	49393
MWENEZI	41927	0	0	0	0	0	0	34986
ZAKA	0	0	0	0	54881	27097	16464	2744
BIKITA	0	0	0	0	10633	4459	14063	18179
CHIVI	2848	0	0	0	0	0	0	0
MUTARE	1899	0	0	0	13720	15778	11662	15092
RUSAPE	20568	0	15030	0	25725	45963	37044	10633
NYANGA	2531	4905	0	0	18865	35672	25725	53166
CHIPINGE	13923	13923	0	4272	5831	15092	10290	29155
BUHERA	0	0	0	0	81635	79234	60026	51451
MUTASA	10284	6645	0	0	34300	20237	5145	4116
NEDZIWA	0	0	0	0	28126	29841	27783	36015
CHIMANIMANI	4588	0	0	0	8232	3087	0	0
System	818920	383987	247448	131951	26068	915820	612262	846533

APPENDIX 2.2 (Answer Report 1)

KAROYI Privatisation Scenario 1 at Full Provet Income Aspiration (Z$ 1,200,000)

Target Cell (Max)

Cell	Name	Original Value	Final Value
$AV$3	Maximize	0.0	1.9

Adjustable Cells

Cell	Name	Original Value	Final Value
$B$2	Activity level Rg1CFin	0.0	39395.5
$C$2	Activity level Rg1SFin	0.0	0.0
$D$2	Activity level RG1CWTP	0.0	39395.5
$E$2	Activity level Rg1SFwtp	0.0	0.0
$F$2	Activity level Rg1SFfmd	0.0	0.0
$G$2	Activity level Rg1CFtc	0.0	39395.5
$H$2	Activity level Rg1SFtc	0.0	0.0
$I$2	Activity level Rg2CFin	0.0	0.0
$J$2	Activity level Rg2SFin	0.0	0.0
$K$2	Activity level RG2CWTP	0.0	0.0
$L$2	Activity level Rg2SFwtp	0.0	0.0
$M$2	Activity level Rg2SFfmd	0.0	0.0
$N$2	Activity level Rg2CFtc	0.0	0.0
$O$2	Activity level Rg2SFtc	0.0	0.0
$P$2	Activity level Rg3CFin	0.0	11391.5
$Q$2	Activity level Rg3SFin	0.0	0.0
$R$2	Activity level RG3CWTP	0.0	11391.5
$S$2	Activity level Rg3SFwtp	0.0	0.0
$T$2	Activity level Rg3SFfmd	0.0	0.0
$U$2	Activity level Rg3CFtc	0.0	11391.5
$V$2	Activity level Rg3SFtc	0.0	0.0
$W$2	Activity level Rg4CFin	0.0	0.0
$X$2	Activity level Rg4SFin	0.0	0.0
$Y$2	Activity level RG4CWTP	0.0	0.0
$Z$2	Activity level Rg4SFwtp	0.0	0.0
$AA$2	Activity level Rg4SFfmd	0.0	0.0
$AB$2	Activity level Rg4CFtc	0.0	0.0
$AC$2	Activity level Rg4SFtc	0.0	0.0
$AD$2	Activity level PRg1SFin	0.0	1372.0
$AE$2	Activity level PRg1SFwt	0.0	1372.0
$AF$2	Activity level PRg1SFfm	0.0	1372.0
$AG$2	Activity level PRg1SFtc	0.0	1372.0
$AH$2	Activity level PRg2SFin	0.0	2416.4
$AI$2	Activity level PRg2SFwt	0.0	2416.4
$AJ$2	Activity level PRg2SFfm	0.0	2416.4
$AK$2	Activity level PRg2SFtc	0.0	2416.4
$AL$2	Activity level PRg3SFin	0.0	2416.4
$AM$2	Activity level PRg3SFwt	0.0	2416.4
$AN$2	Activity level PRg3SFfm	0.0	2416.4
$AO$2	Activity level PRg3SFtc	0.0	2416.4
$AP$2	Activity level PRg4SFin	0.0	2416.4
$AQ$2	Activity level PRg4SFwt	0.0	2416.4
$AR$2	Activity level PRg4SFfm	0.0	2416.4
$AS$2	Activity level PRg4SFtc	0.0	2416.4
$AT$2	Activity level Paravet	0.0	0.0
$AU$2	Activity level Provet	0.0	1.9

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$AX$5	<	39395.5	$AX$5<=$AW$5	Binding	0.0
$AX$6	<	1372.0	$AX$6<=$AW$6	Binding	0.0
$AX$7	<	0.0	$AX$7<=$AW$7	Binding	0.0
$AX$8	<	2416.4	$AX$8<=$AW$8	Not Binding	19192.9
$AX$9	<	11391.5	$AX$9<=$AW$9	Binding	0.0
$AX$10	<	2416.4	$AX$10<=$AW$1	Not Binding	23994.9
$AX$11	<	0.0	$AX$11<=$AW$1	Binding	0.0
$AX$12	<	2416.4	$AX$12<=$AW$1	Not Binding	42517.1
$AX$13	=	0.0	$AX$13=$AW$13	Binding	0.0
$AX$14	=	0.0	$AX$14=$AW$14	Binding	0.0
$AX$15	=	0.0	$AX$15=$AW$15	Binding	0.0
$AX$16	=	0.0	$AX$16=$AW$16	Binding	0.0
$AX$17	=	0.0	$AX$17=$AW$17	Binding	0.0
$AX$18	=	0.0	$AX$18=$AW$18	Binding	0.0
$AX$19	=	0.0	$AX$19=$AW$19	Binding	0.0
$AX$20	=	0.0	$AX$20=$AW$20	Binding	0.0
$AX$21	=	0.0	$AX$21=$AW$21	Binding	0.0
$AX$22	=	0.0	$AX$22=$AW$22	Binding	0.0
$AX$23	=	0.0	$AX$23=$AW$23	Binding	0.0
$AX$24	=	0.0	$AX$24=$AW$24	Binding	0.0
$AX$25	=	0.0	$AX$25=$AW$25	Binding	0.0
$AX$26	=	0.0	$AX$26=$AW$26	Binding	0.0
$AX$27	=	0.0	$AX$27=$AW$27	Binding	0.0
$AX$28	=	0.0	$AX$28=$AW$28	Binding	0.0
$AX$29	=	0.0	$AX$29=$AW$29	Binding	0.0
$AX$30	=	0.0	$AX$30=$AW$30	Binding	0.0
$AX$31	=	0.0	$AX$31=$AW$31	Binding	0.0
$AX$32	=	0.0	$AX$32=$AW$32	Binding	0.0
$AX$33	=	0.0	$AX$33=$AW$33	Binding	0.0
$AX$34	=	0.0	$AX$34=$AW$34	Binding	0.0
$AX$35	=	0.0	$AX$35=$AW$35	Binding	0.0
$AX$36	=	0.0	$AX$36=$AW$36	Binding	0.0
$AX$37	=	0.0	$AX$37=$AW$37	Binding	0.0
$AX$38	=	0.0	$AX$38=$AW$38	Binding	0.0
$AX$39	=	0.0	$AX$39=$AW$39	Binding	0.0
$AX$40	=	0.0	$AX$40=$AW$40	Binding	0.0
$AX$41	=	0.0	$AX$41=$AW$41	Binding	0.0
$AX$42	=	0.0	$AX$42=$AW$42	Binding	0.0
$AX$43	=	0.0	$AX$43=$AW$43	Binding	0.0
$AX$44	=	0.0	$AX$44=$AW$44	Binding	0.0
$AX$45	>	0.0	$AX$45>=$AW$4	Binding	0.0
$AX$46	>	0.0	$AX$46>=$AW$4	Binding	0.0
$B$2	Activity level Rg1CFin	39395.5	$B$2>=0	Not Binding	39395.5
$C$2	Activity level Rg1SFin	0.0	$C$2>=0	Binding	0.0
$D$2	Activity level RG1CWTP	39395.5	$D$2>=0	Not Binding	39395.5
$E$2	Activity level Rg1SFwtp	0.0	$E$2>=0	Binding	0.0
$F$2	Activity level Rg1SFfmd	0.0	$F$2>=0	Binding	0.0
$G$2	Activity level Rg1CFtc	39395.5	$G$2>=0	Not Binding	39395.5
$H$2	Activity level Rg1SFtc	0.0	$H$2>=0	Binding	0.0
$I$2	Activity level Rg2CFin	0.0	$I$2>=0	Binding	0.0
$J$2	Activity level Rg2SFin	0.0	$J$2>=0	Binding	0.0
$K$2	Activity level RG2CWTP	0.0	$K$2>=0	Binding	0.0
$L$2	Activity level Rg2SFwtp	0.0	$L$2>=0	Binding	0.0
$M$2	Activity level Rg2SFfmd	0.0	$M$2>=0	Binding	0.0
$N$2	Activity level Rg2CFtc	0.0	$N$2>=0	Binding	0.0
$O$2	Activity level Rg2SFtc	0.0	$O$2>=0	Binding	0.0
$P$2	Activity level Rg3CFin	11391.5	$P$2>=0	Not Binding	11391.5
$Q$2	Activity level Rg3SFin	0.0	$Q$2>=0	Binding	0.0
$R$2	Activity level RG3CWTP	11391.5	$R$2>=0	Not Binding	11391.5
$S$2	Activity level Rg3SFwtp	0.0	$S$2>=0	Binding	0.0
$T$2	Activity level Rg3SFfmd	0.0	$T$2>=0	Binding	0.0
$U$2	Activity level Rg3CFtc	11391.5	$U$2>=0	Not Binding	11391.5
$V$2	Activity level Rg3SFtc	0.0	$V$2>=0	Binding	0.0
$W$2	Activity level Rg4CFin	0.0	$W$2>=0	Binding	0.0
$X$2	Activity level Rg4SFin	0.0	$X$2>=0	Binding	0.0
$Y$2	Activity level RG4CWTP	0.0	$Y$2>=0	Binding	0.0
$Z$2	Activity level Rg4SFwtp	0.0	$Z$2>=0	Binding	0.0
$AA$2	Activity level Rg4SFfmd	0.0	$AA$2>=0	Binding	0.0
$AB$2	Activity level Rg4CFtc	0.0	$AB$2>=0	Binding	0.0
$AC$2	Activity level Rg4SFtc	0.0	$AC$2>=0	Binding	0.0
$AD$2	Activity level PRg1SFin	1372.0	$AD$2>=0	Not Binding	1372.0
$AE$2	Activity level PRg1SFwt	1372.0	$AE$2>=0	Not Binding	1372.0
$AF$2	Activity level PRg1SFfm	1372.0	$AF$2>=0	Not Binding	1372.0
$AG$2	Activity level PRg1SFtc	1372.0	$AG$2>=0	Not Binding	1372.0
$AH$2	Activity level PRg2SFin	2416.4	$AH$2>=0	Not Binding	2416.4
$AI$2	Activity level PRg2SFwt	2416.4	$AI$2>=0	Not Binding	2416.4
$AJ$2	Activity level PRg2SFfm	2416.4	$AJ$2>=0	Not Binding	2416.4
$AK$2	Activity level PRg2SFtc	2416.4	$AK$2>=0	Not Binding	2416.4
$AL$2	Activity level PRg3SFin	2416.4	$AL$2>=0	Not Binding	2416.4
$AM$2	Activity level PRg3SFwt	2416.4	$AM$2>=0	Not Binding	2416.4
$AN$2	Activity level PRg3SFfm	2416.4	$AN$2>=0	Not Binding	2416.4
$AO$2	Activity level PRg3SFtc	2416.4	$AO$2>=0	Not Binding	2416.4
$AP$2	Activity level PRg4SFin	2416.4	$AP$2>=0	Not Binding	2416.4
$AQ$2	Activity level PRg4SFwt	2416.4	$AQ$2>=0	Not Binding	2416.4
$AR$2	Activity level PRg4SFfm	2416.4	$AR$2>=0	Not Binding	2416.4
$AS$2	Activity level PRg4SFtc	2416.4	$AS$2>=0	Not Binding	2416.4
$AT$2	Activity level Paravet	0.0	$AT$2>=0	Not Binding	0.0
$AU$2	Activity level Provet	1.9	$AU$2>=0	Not Binding	1.9

APPENDIX 2.3 (Answer Report 2)

Karoyi Privatisation Scenario 1 at 80 Percent of Current Provet Income Aspiration (Z$ 960,000)

Target Cell (Max)

Cell	Name	Original Value	Final Value
$AV$3	Maximize	0	2.3

Adjustable Cells

Cell	Name	Original Value	Final Value
$B$2	Activity level Rg1CFin	0	39395.5
$C$2	Activity level Rg1SFin	0	0.0
$D$2	Activity level RG1CWT	0	39395.5
$E$2	Activity level Rg1SFwtp	0	0.0
$F$2	Activity level Rg1SFfmd	0	0.0
$G$2	Activity level Rg1CFtc	0	39395.5
$H$2	Activity level Rg1SFtc	0	0.0
$I$2	Activity level Rg2CFin	0	0.0
$J$2	Activity level Rg2SFin	0	0.0
$K$2	Activity level RG2CWT	0	0.0
$L$2	Activity level Rg2SFwtp	0	0.0
$M$2	Activity level Rg2SFfmd	0	0.0
$N$2	Activity level Rg2CFtc	0	0.0
$O$2	Activity level Rg2SFtc	0	0.0
$P$2	Activity level Rg3CFin	0	11391.5
$Q$2	Activity level Rg3SFin	0	0.0
$R$2	Activity level RG3CWT	0	11391.5
$S$2	Activity level Rg3SFwtp	0	0.0
$T$2	Activity level Rg3SFfmd	0	0.0
$U$2	Activity level Rg3CFtc	0	11391.5
$V$2	Activity level Rg3SFtc	0	0.0
$W$2	Activity level Rg4CFin	0	0.0
$X$2	Activity level Rg4SFin	0	0.0
$Y$2	Activity level RG4CWT	0	0.0
$Z$2	Activity level Rg4SFwtp	0	0.0
$AA$2	Activity level Rg4SFfmd	0	0.0
$AB$2	Activity level Rg4CFtc	0	0.0
$AC$2	Activity level Rg4SFtc	0	0.0
$AD$2	Activity level PRg1SFin	0	1372.0
$AE$2	Activity level PRg1SFwt	0	1372.0
$AF$2	Activity level PRg1SFf	0	1372.0
$AG$2	Activity level PRg1SFtc	0	1372.0
$AH$2	Activity level PRg2SFin	0	1933.1
$AI$2	Activity level PRg2SFwt	0	1933.1
$AJ$2	Activity level PRg2SFf	0	1933.1
$AK$2	Activity level PRg2SFtc	0	1933.1
$AL$2	Activity level PRg3SFin	0	1933.1
$AM$2	Activity level PRg3SFwt	0	1933.1
$AN$2	Activity level PRg3SFf	0	1933.1
$AO$2	Activity level PRg3SFtc	0	1933.1
$AP$2	Activity level PRg4SFin	0	1933.1
$AQ$2	Activity level PRg4SFwt	0	1933.1
$AR$2	Activity level PRg4SFf	0	1933.1
$AS$2	Activity level PRg4SFtc	0	1933.1
$AT$2	Activity level Paravet	0	0.0
$AU$2	Activity level Provet	0	2.3

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$AX$5	<	39395.5	$AX$5<=$AW$5	Binding	0.0
$AX$6	<	1372.0	$AX$6<=$AW$6	Binding	0.0
$AX$7	<	0.0	$AX$7<=$AW$7	Binding	0.0
$AX$8	<	1933.1	$AX$8<=$AW$8	Not Binding	19676.1
$AX$9	<	11391.5	$AX$9<=$AW$9	Binding	0.0
$AX$10	<	1933.1	$AX$10<=$AW$10	Not Binding	24478.2
$AX$11	<	0.0	$AX$11<=$AW$11	Binding	0.0
$AX$12	<	1933.1	$AX$12<=$AW$12	Not Binding	43000.4
$AX$13	=	0.0	$AX$13=$AW$13	Binding	0.0
$AX$14	=	0.0	$AX$14=$AW$14	Binding	0.0
$AX$15	=	0.0	$AX$15=$AW$15	Binding	0.0
$AX$16	=	0.0	$AX$16=$AW$16	Binding	0.0
$AX$17	=	0.0	$AX$17=$AW$17	Binding	0.0
$AX$18	=	0.0	$AX$18=$AW$18	Binding	0.0
$AX$19	=	0.0	$AX$19=$AW$19	Binding	0.0
$AX$20	=	0.0	$AX$20=$AW$20	Binding	0.0
$AX$21	=	0.0	$AX$21=$AW$21	Binding	0.0
$AX$22	=	0.0	$AX$22=$AW$22	Binding	0.0
$AX$23	=	0.0	$AX$23=$AW$23	Binding	0.0
$AX$24	=	0.0	$AX$24=$AW$24	Binding	0.0
$AX$25	=	0.0	$AX$25=$AW$25	Binding	0.0
$AX$26	=	0.0	$AX$26=$AW$26	Binding	0.0
$AX$27	=	0.0	$AX$27=$AW$27	Binding	0.0
$AX$28	=	0.0	$AX$28=$AW$28	Binding	0.0
$AX$29	=	0.0	$AX$29=$AW$29	Binding	0.0
$AX$30	=	0.0	$AX$30=$AW$30	Binding	0.0
$AX$31	=	0.0	$AX$31=$AW$31	Binding	0.0
$AX$32	=	0.0	$AX$32=$AW$32	Binding	0.0
$AX$33	=	0.0	$AX$33=$AW$33	Binding	0.0
$AX$34	=	0.0	$AX$34=$AW$34	Binding	0.0
$AX$35	=	0.0	$AX$35=$AW$35	Binding	0.0
$AX$36	=	0.0	$AX$36=$AW$36	Binding	0.0
$AX$37	=	0.0	$AX$37=$AW$37	Binding	0.0
$AX$38	=	0.0	$AX$38=$AW$38	Binding	0.0
$AX$39	=	0.0	$AX$39=$AW$39	Binding	0.0
$AX$40	=	0.0	$AX$40=$AW$40	Binding	0.0
$AX$41	=	0.0	$AX$41=$AW$41	Binding	0.0
$AX$42	=	0.0	$AX$42=$AW$42	Binding	0.0
$AX$43	=	0.0	$AX$43=$AW$43	Binding	0.0
$AX$44	=	0.0	$AX$44=$AW$44	Binding	0.0
$AX$45	>	0.0	$AX$45>=$AW$45	Binding	0.0
$AX$46	>	0.0	$AX$46>=$AW$46	Binding	0.0
$B$2	Activity level Rg1CFin	39395.5	$B$2>=0	Not Binding	39395.5
$C$2	Activity level Rg1SFin	0.0	$C$2>=0	Binding	0.0
$D$2	Activity level RG1CWT	39395.5	$D$2>=0	Not Binding	39395.5
$E$2	Activity level Rg1SFwtp	0.0	$E$2>=0	Binding	0.0
$F$2	Activity level Rg1SFfmd	0.0	$F$2>=0	Binding	0.0
$G$2	Activity level Rg1CFtc	39395.5	$G$2>=0	Not Binding	39395.5
$H$2	Activity level Rg1SFtc	0.0	$H$2>=0	Binding	0.0
$I$2	Activity level Rg2CFin	0.0	$I$2>=0	Binding	0.0
$J$2	Activity level Rg2SFin	0.0	$J$2>=0	Binding	0.0
$K$2	Activity level RG2CWT	0.0	$K$2>=0	Binding	0.0
$L$2	Activity level Rg2SFwtp	0.0	$L$2>=0	Binding	0.0
$M$2	Activity level Rg2SFfmd	0.0	$M$2>=0	Binding	0.0
$N$2	Activity level Rg2CFtc	0.0	$N$2>=0	Binding	0.0
$O$2	Activity level Rg2SFtc	0.0	$O$2>=0	Binding	0.0
$P$2	Activity level Rg3CFin	11391.5	$P$2>=0	Not Binding	11391.5
$Q$2	Activity level Rg3SFin	0.0	$Q$2>=0	Binding	0.0
$R$2	Activity level RG3CWT	11391.5	$R$2>=0	Not Binding	11391.5
$S$2	Activity level Rg3SFwtp	0.0	$S$2>=0	Binding	0.0
$T$2	Activity level Rg3SFfmd	0.0	$T$2>=0	Binding	0.0
$U$2	Activity level Rg3CFtc	11391.5	$U$2>=0	Not Binding	11391.5
$V$2	Activity level Rg3SFtc	0.0	$V$2>=0	Binding	0.0
$W$2	Activity level Rg4CFin	0.0	$W$2>=0	Binding	0.0
$X$2	Activity level Rg4SFin	0.0	$X$2>=0	Binding	0.0
$Y$2	Activity level RG4CWT	0.0	$Y$2>=0	Binding	0.0
$Z$2	Activity level Rg4SFwtp	0.0	$Z$2>=0	Binding	0.0
$AA$2	Activity level Rg4SFfmd	0.0	$AA$2>=0	Binding	0.0
$AB$2	Activity level Rg4CFtc	0.0	$AB$2>=0	Binding	0.0
$AC$2	Activity level Rg4SFtc	0.0	$AC$2>=0	Binding	0.0
$AD$2	Activity level PRg1SFin	1372.0	$AD$2>=0	Not Binding	1372.0
$AE$2	Activity level PRg1SFwt	1372.0	$AE$2>=0	Not Binding	1372.0
$AF$2	Activity level PRg1SFf	1372.0	$AF$2>=0	Not Binding	1372.0
$AG$2	Activity level PRg1SFtc	1372.0	$AG$2>=0	Not Binding	1372.0
$AH$2	Activity level PRg2SFin	1933.1	$AH$2>=0	Not Binding	1933.1
$AI$2	Activity level PRg2SFwt	1933.1	$AI$2>=0	Not Binding	1933.1
$AJ$2	Activity level PRg2SFf	1933.1	$AJ$2>=0	Not Binding	1933.1
$AK$2	Activity level PRg2SFtc	1933.1	$AK$2>=0	Not Binding	1933.1
$AL$2	Activity level PRg3SFin	1933.1	$AL$2>=0	Not Binding	1933.1
$AM$2	Activity level PRg3SFwt	1933.1	$AM$2>=0	Not Binding	1933.1
$AN$2	Activity level PRg3SFf	1933.1	$AN$2>=0	Not Binding	1933.1
$AO$2	Activity level PRg3SFtc	1933.1	$AO$2>=0	Not Binding	1933.1
$AP$2	Activity level PRg4SFin	1933.1	$AP$2>=0	Not Binding	1933.1
$AQ$2	Activity level PRg4SFwt	1933.1	$AQ$2>=0	Not Binding	1933.1
$AR$2	Activity level PRg4SFf	1933.1	$AR$2>=0	Not Binding	1933.1
$AS$2	Activity level PRg4SFtc	1933.1	$AS$2>=0	Not Binding	1933.1
$AT$2	Activity level Paravet	0.0	$AT$2>=0	Not Binding	0.0
$AU$2	Activity level Provet	2.3	$AU$2>=0	Not Binding	2.3

APPENDIX 2.4:

Disk Copy of Linear Programming Model for Animal Health Services in Zimbabwe

(Disk may be found in the pocket attached to the inside back cover)

APPENDIX 3: SAMPLE QUESTIONNAIRE

3.1 Sample questionnaire for livestock producers in Zimbabwe

APPENDIX 3.1

Sample Questionnaire for Livestock Producers in Zimbabwe

CONFIDENTIAL

(This is a private survey and not intended for any commercial use. All information provided will be treated as confidential. Please fold completed forms and send to the address on the back of the forms, freepost).

Please tick the boxes or fill in the spaces provided as appropriate.

No	Questions	Response
1	Name (of farm)	
2	Location (of farm)	
3	District	
4	Category of farm- Commercial livestock	
	- Agro-livestock	
5	Distance of farm from nearest vet. clinic	
6	Distance (of farm) from nearest city	
7	Number of animals owned- Cattle (total)	
	- Cattle (Dairy)	
	- Sheep & goats	
	- Horses/donkey	
	- Pigs	
	- Poultry	
	- Cats & dogs	
8	Number of animals sold last year- Cattle	
	- Others	
9	Other sources of income last year	
10	Total number of visit by/to the vet last year	
11	Total veterinary expenditure last year	
12	Cost of vet drugs from stores /merchants	
13	What treatments do you perform yourself?	
14	Who else provides you with vet advice?	
15	Which vet. services do you receive free?	
16	Which vet. services should you get free?	
17	Would you pay if fees increase by - 10%?	Yes ☐ No ☐
	- 50%	Yes ☐ No ☐
	- 100%	Yes ☐ No ☐
18	Are your vet services satisfactory? (Y/N)	Yes ☐ No ☐
19	Suggestions on improving vet. services	

N.B.

Please where numbers or figures are required, an estimate or approximation will suffice. Thank you.

APPENDIX 4:- PUBLICATIONS

4.1 Copies of Abstracts

4.2 Copy of Poster

4.3 Copies of Conference Proceedings Published

Abstract

Evaluating the impact on poverty of social and health care policy reforms in Africa: A case for the use of Precision Service Delivery technique (PSD) in health care management[1].

ODEYEMI, I.A.O., LILWALL, N.B. and WILSON, R.L.
Institute of Ecology and Resource Management
The University of Edinburgh
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Persistent economic constraints in most developing countries resulted in their inability to adequately fund a health care delivery system. Social and health care reforms which include the introduction of market-led economy and the policy of privatisation of the hitherto government delivered services, has been proposed as a means of improving services in such countries. Studies however suggest that the adoption of such policy reforms further adversely affect access to services especially by rural households, in some cases resulting in poverty and destitution. The development of a framework for the planning monitoring and evaluating of social and health care policies so as to avoid such adverse effect is the subject of this paper. The concept of Precision Service Delivery (PSD) in the planning and implementation of social and health care policies is introduced. It involves the use of geospatial and econometric models in accurately profiling the socio-economic and other demographic characteristics of the population within the delivery system. This ensures that social as well as health care reforms are area-specific and introduced policy initiatives are appropriate and targeted at the right segment of the society. It provides a means of ensuring equity and preventing further marginalisation of the poor. The delivery of health care services in the livestock industry of Zimbabwe provides the case study for this paper.

Key Words:
Cost-Effective, Equity, Geospatial Models, Health care, Precision Service Delivery (PSD), Social Reforms.

1

Presented at the Workshop on "Building and Sustaining of the Capacity for Social Policy Reforms". Tangier, Morocco, December 1-3, 1998.

[2]SOCIO-ECONOMIC CHARACTERISATION OF THE LIVESTOCK PRODUCTION SYSTEMS IN AFRICA: AN ANIMAL HEALTH SERVICES DELIVERY PERSPECTIVE.

Odeyemi, I.A.O. Lilwall, B.N. and Wilson, R.L.
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Scotland, United Kingdom

The diversity inherent in the livestock production systems in most developing countries and particularly in Africa, has led many to believe that poor and rural livestock dependent populations within extensive production systems are likely to be unwilling and less able to pay for privatised services. Using socio-economic data from field survey of a province of Zimbabwe, the method of Principal Component Analysis, Multiple Regression Model and then Discriminant Analysis were used to aggregate and determine the role of the putative characteristics of the four known livestock production systems in Zimbabwe. Wealth, presence of other sources of income and a favourable perception of the quality of existing animal health services are the significant characteristics of the production systems when demand is measured in terms of Veterinary Coverage. However, where the index of demand is the herd Veterinary Expenditure, proximity of the farms to cities, commercial objective of the farm and the intrinsic willingness of the farmer to pay for services are the significant factors. The constellation of conditions favourable for high uptake of veterinary services is not unique to any particular production system. This study thus suggests that, veterinary uptake or demand for veterinary services in any particular country or region, is not entirely a factor of the production system.

Key Words:
Animal health services, Privatisation, Socio-economic factors, Livestock production.

[2] Presented at the Ninth International Conference of Institutes of Tropical Veterinary Medicine, 14th -17th September 1998, Harare, Zimbabwe.

[3]MANAGING AGRICULTURAL SERVICES DELIVERY IN LESS FAVOURED AREAS: A ROLE FOR GEOSPATIAL MODELS.

I.A.O. Odeyemi[1], D.C. Finnegan[2], N.B. Lilwall[1], R.M. Wilson[1] and R.L. Hodgart[2]
Institute of Ecology and Resource Management[1], Department of Geography[2], University of Edinburgh,
Scotland, United Kingdom.

ABSTRACT:

The adoption of free market reforms and privatisation in developing economies has resulted in millions of people within poor and rural farming communities being further marginalised and becoming destitute by policies emanating from central governments. This paper explores a hybrid methodology for improving service delivery to farmers through a more rational and equitable decision making process on resource allocation and management. Location-allocation modelling techniques have been used for some time in helping to deliver services, frequently as part of a larger spatial decision support system. Genetic algorithms, a search and optimisation process which mimics biological evolution, can be configured into a form suitable for location-allocation modelling. They provide some significant advantages over existing location-allocation methods both in terms of quality of end results, and in the flexibility of their use. Using the delivery of animal health services to the livestock industry in Zimbabwe as a case study, this paper describes how a genetic algorithm can be used together with a gradient search method to find highly efficient and equitable locations for these services. Outputs from the model are then used to evaluate issues relating to equity of access, restructuring of existing infrastructure, and viability and sustainability of facilities. Finally, we discuss how the genetic algorithm may be modified to handle multiple criteria, and how the methodology can be applied to budgeting for agricultural extension services and human resource allocation as well as environmental impact assessment of agricultural policies.

Key words:
Spatial decision support system, Location-allocation model, Genetic algorithm, Search and optimisation, Multiple criteria analysis, Animal health services, Privatisation, Resource management.

---

[3] *Presented at the First International Conference on Geospatial Information in Agriculture and Forestry, Lake Beuna Vista, Florida, 1-3 June 1998.

Poster presented at the European Association of Agricultural Economics Conference, Edinburgh, Scotland, 1997

Evaluating Animal Health Delivery Services (AHDS) In Africa Using Location-Allocation (L-A) Models

Odeyemi, I.A.O.[1], Lilwall, N.B.[1], Wilson, R.N.[1], Finnegan, D.C.[2], & Hodgart, R.L.[2]
[1]Institute of Ecology and Resource Management, University of Edinburgh, Scotland,UK
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BACKGROUND

AHDS

Difficulty of quantifying and qualifying demand for veterinary services results in sub-optimal resource allocation and management.

L-A MODELS

Address the problem of locating a set of facilities such that they are as accessible to the population as possible.

Utilise Euclidean space (straight line) or network (existing roads).

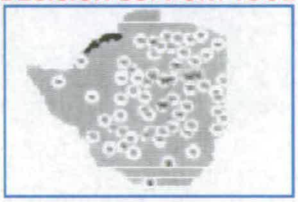
Minimise aggregate travel distance by population or maximises attendance (usage) of facilities.

DECISION ANALYSIS

Manipulates output data from L-A using coefficients derived from population surveys.

Produces appropriate indices for evaluating service delivery.

DECISION SUPPORT TOOL



Practice Viability Index for Zimbabwe

MODELLING FRAMEWORK

INPUT DATA

Co-ordinates (lat-long) of all population centres (demand points) and location of existing facilities (supply points)

Population figures (human or livestock) of each demand point

Socio-economic or production coefficients of each population unit

OUTPUT DATA

Aggregate travel distance by whole population

Mean and maximum travel distance (costs) by population allocated to facilities

Proportion of total population allocated to each facility within specified distances

DECISION ANALYSIS

APPLICATIONS

Cost-benefit considerations

Viability /sustainability of facilities

Budgeting for disease control

Issues of equity of access

Relocation alternatives for facilities

Manning levels and manpower projections

Optimum facility capacity determination

Environmental impact analysis of policies

Zentralstelle für Ernährung und Landwirtschaft (ZEL) – Feldafing und Zschortau
Food and Agriculture Development Centre

AITVM
Association of Institutions
of Tropical Veterinary
Medicine

AITVM

Zessin, Karl-Hans (ed.)

Livestock Production and Diseases in the Tropics: Livestock Production and Human Welfare

Proceedings of the VIII International Conference of Institutions of Tropical Veterinary Medicine

Volume II

Livestock Production & Diseases. Proc. 8th Conf. Inst. Trop. Vet. Med., Berlin, Germany, 1995

4.3
INCREASING THE EFFICIENCY OF LIVESTOCK SERVICES DELIVERY SYSTEMS - THE CASE FOR POLICY STUDIES AS A DISCIPLINE IN TROPICAL VETERINARY INSTITUTIONS.

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Centre for Tropical Veterinary Medicine, University of Edinburgh, Roslin, EH25 9RE, Midlothian, Scotland

INTRODUCTION

Most developing countries are in the tropics, and despite the diversities in their political and socio-economic history, there is a lot of similarities in the evolution of their institutions of delivery of veterinary services. They appear to have passed through four recognisable phases (Table 1), with their structural dynamics exhibiting the classical veterinary epidemiological revolutions (Schwabe, 1982; Schwabe, 1993). A brief analysis of the earlier era is necessary, so as to identify the sources, the different types and the impact of the policies responsible for the formation of the current institutions of delivery of animal health services seen in the tropics.

Table 1. Evolution of the Institutions of Delivery of Animal Health Services in the Tropics.

Phases	Characteristics
I. Pre-institutional Era (Before the 1880s)	- Absence of orthodox veterinary medicine - Ethno-veterinary practises - Poor knowledge of diseases - Frequent disease outbreaks
II. Era of Colonial Veterinary Institutions (1880s-1960s)	- Introduction of orthodox veterinary medicine - Development of veterinary departments - Formal and informal veterinary training - Improvement in livestock breeding
III. Post Independence Era (1960s -early 1980s)	- Inherited colonial departments and policies - Staff development programmes - Expansion of veterinary infrastructure - Nationalisation of livestock industry
IV. Privatisation Era (Mid 1980s upwards)	- Public sector reforms - Cost recovery and privatisation - Liberalisation of drug/ input distribution - Intenational agencies/ NGO participation

The pre-institutional era, which was the earliest, was characterised by the absence of organised veterinary institutions, while the indigenous animal health services that was available, was provided and procured by private arrangement between clients. Orthodox veterinary medicine as we know it today was introduced by the colonial administrations following the arrival of veterinarians at the turn of the century. The veterinary departments provided clinical and diagnostic services, research and training, policy formulation and advisory services, often free of charge. At independence therefore, African countries subsequently inherited completely without change, the veterinary institutions and policies of the colonial administrations.

The newly independent African governments under-took ambitious staff development and expansion programmes resulting in over-staffing, meanwhile, global economic recession coupled with administrative inefficiencies, meant that the governments were later unable to adequately fund the delivery of animal health services, resulting in a deterioration of services and the subsequent advocation for re-structuring and privatisation of some services (De Haan and Bekure, 1991). The scenario above created an opportunity for greater participation of international funding agencies and NGOs in policy formulation and implementation of animal health delivery services in the tropics, especially as acceptance of such policies became conditions for project funding. It has also emerged that the international agenda which overwhelmingly influence the privatisation era, has introduced different perspectives from the new participants into the delivery system (Appendix 1).

Since the introduction of the privatisation and restructuring policies however, studies conducted have thus revealed the emergence of several structures and issues which are perceived to have an influence on the success or otherwise of the introduced initiatives (Odeyemi, 1994b; Umali et al., 1992). The lack of impact associated with some ongoing privatisation and restructuring projects, further underscore the need to adequately understand the various issues at play in the delivery systems of the tropics, so as to apply the appropriate mix of perspectives into the introduced interventions (Appendix 2 and 3).

THE PRIVATISATION POLICY

The policy to re-structure the livestock sector and privatise aspects of the delivery of animal health services has brought to the fore, more than anything else, the need to undertake area-specific studies in the formulation of animal health policies. The appropriateness of health delivery models for different regions and production systems, the role description for public versus private participants, as well as the viability and sustainability of a commercially delivered veterinary service, are but a few of the issues that require careful studies (Odeyemi, 1993). As analysis of the current state of the privatisation policy in several African countries continue to point to poor impact and uptake by the target countries, the need for appropriate animal health information systems, the development of appropriate training and skills for participants as well as participatory approach to the planning and implementation of policies become more apparent (Gros, 1994; Mlangwa and Kisauzi, 1994a; Mlangwa and Kisauzi, 1994b; Odeyemi, 1994c; Sollod and Stem, 1991).

The development of a Veterinary Practice Management Course, such as exists at the Centre for Tropical Veterinary Medicine, Edinburgh, to provide much needed business skills for intending private practitioners in the tropics is particularly useful. Meanwhile policy studies in the area of veterinary education and manpower, as well as veterinary drug and input supply strategies are equally essential to the commercial delivery of animal health services, especially in the light of the often fragile and unfavourable economic environment in most countries (Odeyemi, 1994a). Similarly, in view of the prevailing limited private practice experience, the role of veterinary associations, local banking and business institutions require careful consideration and further studies.

THE NGO PHENOMENON

The inability of African and other developing countries to adequately fund the delivery of animal health services, made this sector attractive to both local and especially international Non-Governmental Organisations (NGO), with their developmental objectives. NGOs are the proponents of lower level technologies in the delivery of services, and para-veterinary and community-based workers, as well as the promotion of ethno-veterinary knowledge systems are but a few of their areas of emphasis. Because of their developmental objectives, NGOs are often non-profit making and this is reflected in their policies and the services they deliver, while their emphasis is more social rather than economic impact, a situation often incompatible with privatisation objectives.

The differences in the objectives of the various NGOs, the lack of co-ordination between them and their ignorance of third world cultures and socio-political realities, have been identified as constraints to the success of their interventions (Schneider, 1988; Swift and Toulmin, 1992). The socio-political and economic diversities in the tropics, the unfavourable economic environment, and the differences in the types and objectives of the various participants are major constraints to the animal health delivery systems which underscore the need for area-specific, multi-disciplinary studies in the development of appropriate policies.

OTHER DEVELOPMENTAL ISSUES

Several "politically acceptable" issues that engage the political agendas of the developed world are now appearing in development literature, and influencing policies and projects planned for the tropics. Issues such as animal welfare, the environment and gender issues, although very important are very complex and poorly understood in the African and developing country context. The variations that exist between and within countries on these issues make any generalisation unwise.

Gender issues in the delivery of animal health services essentially involve the role and proportion of the different sexes either as receivers or deliverers of services. There are very few studies conducted for the tropics to determine the trends and proportion of the sexes in the veterinary profession (Odeyemi, 1994b), and even fewer studies to establish their roles and how to maximise them. However, several socio-economic studies conducted have looked at the sexes as members of farming or livestock producing households, who are therefore, recipients of animal health services and other input of development (Charlton, 1984). Even from these studies, very few general trends have emerged and the extrapolation of the results require a lot of caution due to the prevailing socio-political and economic differences.

Animal welfare issues in the tropics are different from those of developed countries, and have received even less attention due to the obvious complexity of the socio-economic environments of the countries vis-à-vis the rather rigid animal welfare regulations for the veterinary profession and veterinary services in developed countries (Mayer, 1994). However, discussions are going on with respect to the treatment of equines and other animals used for draught purposes, the farming of game animals and the culling and management of wildlife. While efforts are being made in the understanding of these various developmental issues, only carefully targeted and co-ordinated multi-disciplinary studies will provide the required information for the development of appropriate policies and programmes (Anonymous, 1995; Swift and Toulmin, 1992).

CONCLUSION

A careful analysis of the evolution of the institutions of delivery of animal health services in the tropics reveals that, the initiatives in the planning and implementation of animal health policies in developing countries have now largely shifted from the governments of the respective countries in the region and are firmly held by international organisations and their local agencies, due in part to their control of the means of funding the services. Needless to say that, political, socio-economic and environmental issues that have emerged in the delivery systems and the different interventions tried are all quite relevant, all-be-it, reflecting different perspectives to varying extent. However, the lack of impact being witnessed with most animal health interventions is largely due to in-adequate and inappropriate information available to planners and veterinary personnel.

It is important to note the over-riding role of various national and international agencies in the delivery system, who rather than having a co-ordinated and holistic approach to project planning and implementation, have diverse and often conflicting objectives, which often result in different and narrow policy and project focus. The dearth of useful and relevant data on the very diverse animal health delivery systems of the tropics has meant therefore that, veterinarians and planners have had to make do with extrapolated data from other regions and fields, often with unfavourable results. Thus, policies aimed at Africa, even with the best of intentions, and supported by international financial and technical resources, have been shown not to be very successful, because they are not area-specific, and they continue to be implemented within uninformed populations, reluctant local bureaucracies and the absence of local favourable support infrastructure.

The development of appropriate information systems and quality data collection methodologies, as well as area-specific and participatory approach to animal health policy planning and implementation, will in addition to providing the necessary area-specific information, also create policy awareness and acceptability within target populations and bureaucracies, a situation hitherto lacking, and clearly constraining existing animal health delivery programmes in developing countries. A holistic and multi-disciplinary approach is now required in the solving of the emerging problems of these animal health delivery systems in the tropics. However, direct extrapolation from other industries have been shown to be inappropriate, while specialists from such industries have consistently failed to present an accurate veterinary perspective to policy problems and issues, thus, a clear case is made for the development of veterinary policy studies as a discipline. Institutions of tropical veterinary medicine, in addition to providing the traditional clinical training for the professionals of the region, must also develop appropriate policy study capabilities, to meet the immediate and long term policy needs of the changing animal health systems of the tropics in a more appropriate and sustainable way, thereby, strengthening the planning and advisory capabilities of the regional institutions.

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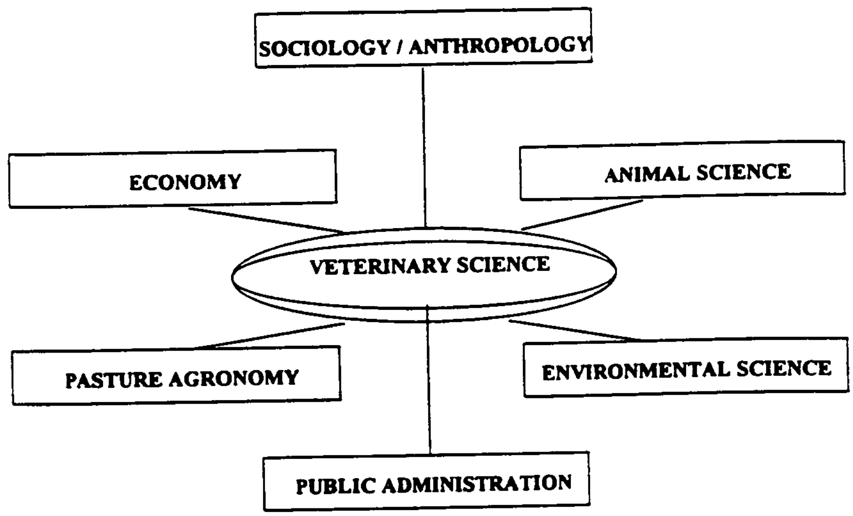
Appendix 1: Organisational dynamics and influences (of the Animal Health Delivery System)

PHASES	ORGANISATIONAL DYNAMICS	PREDOMINANT INFLUENCES
I. Pre-institutional Era (Before the 1880s	- Private delivery	- Private agenda.
II. Era of Colonial Veterinary Institutions (1880s-1960s)	-Public delivery emerging.	- Colonial agenda.
III. Post Independence Era (1960s -early 1980s)	-Public delivery	- Political agenda.
IV. Privatisation Era (Mid 1980s upwards)	- Private delivery re-emerging?	- International agenda

Appendix 2: The different perspectives (on the Animal Health Delivery System)

DISCIPLINES	PERSPECTIVES
- Veterinary Medicine	- Disease eradication.
- Animal Science	- Output per unit of livestock.
- Pasture Agronomy	- Output per natural forage.
- Economics /Industry	- Cost benefit consideration.
- Sociology /Anthropology	- Social implications /benefits.
- Public Administration	- Political considerations.
- Environmental Science	- Environmental impact.

Appendix 3: Animal health delivery systems in the tropics:
-(the appropriate perspective).



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Indian Veterinary Association

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Location-Allocation Modelling : A New Approach To The Planning, Evaluation And Monitoring Of Animal Health Delivery Services.

I.A.O. Odeyemi, N.B. Lilwall, R.M.Wilson[1], D. Finnegan

Institute of Ecology and [1] Resource Management., Department of Geography,,
University of Edinlurgh, Scotland, United Kingdom

Current trends in the delivery of animal Health services in the topics :

All over Africa and in other developing economies. persistent budgetary constraint is fo governments to re-structure and adopt free market reforms including the privatisation of their veteri services (de Haan and Bckure 1991). For similar reasons, as well as the need for better accounta and good governance, administrators, projects managers, researchers and field personnel are required to be able to quantity the socio-economic benefits as well as the environmental impac disease control programmes and other immatives aimed at enhancing the productivity of livesto developing countries. Thus, in addition to achieving the clinical and production objections, initiativ also expected to be viable and sustainable, and these must e quantifiable. The absence of plan tools specifically for the animal health delivery system has meant that, past attempts at achievin above set of objecties have not been very successful. Such efforts have therefore resulted in millio people within poor and rural communities being further marginalised and becoming destitute by po emanating from central governments or from other institutions responsible for delivery of servic producers.

Emerging Problems

The dilemma for the authorities and planners involved in the implementation of the on-going ch within the delivery system has been the difficulty of quantifying and qualifiying availability and deman veterinary service. Financial and human resources as well as clinical facilities are therefore not optir allocated or managed, with consequences for millions of rural and poor livestock dependent househ The net effect of the current restructuring and privitisation policy has been a general decline in avai health care especially to poor and rural producers. For instance, most government departments withdrawing from the delivery of veterinary clinical services to producers so that these could be t over by the private sector. In most cases however, the private sector is yet to take off. Another compo of the restructuring exercise is the "down sizing" of the department, which in essence involves the clo of a number of veterinary facilities as well as the retrenchment of sulplus staff. Unforunately, this only created further veterinary unemployment which now ranges between 15% to 45% across Afric government veterinarians as well as fresh graduates lack the confidence to set up private practices estimated that by the turn of the century, less than one quarter of the rural livestock population Afric be receiving adequate clinical services. Ironically by then, less than half of the trained veterinary pers will be gainfully employed in the veterinary field (Odeyemi et al 1997) There is therefore a nee ameans of stemming the ongoing decline in services by providing planners as well as field perso with appropriate decision support tool essential box a more efficient delivery of animal health ser especially to the poor and rural livestock producers, that way enhancing the productivity of their lives ameliorating their poverty and improving their environment as well as their general well-being.

The Model

Location-allocation models provide a means of spatially quantifying and qualifying any prescribed attribute as it relats to a given population, human or livestock. In this case, it is specifically designed to address the various planning issues relating to the delivery of animal health services. It is based on location - allocation modelling techniques which have been used in other industries for some time in helping to delivery services. Frequently as part of a larger spatial decision support system (Rushton, 1988). The software itself is Written in C++ language and PC Based, in a Microsoft Windows operating system with possible portability to UNIX / X Windows workstation. A simple Graphical User Interface (GUI) is employed and data import is possible through popular formats such a Microsoft Excel and Microsoft Access.

Outputs of the model can them be linked to various Geographical Information System (GIS) packages to enhance the visual presentation of the special charcteristics of the results.

Model Outputs

The location - allocation model essentially attempts to provide optimum location for a number of facilities such that the service provided by the facilities is accessible to the population in the most efficient way. The allocation of population units to facilities is based on the nearest neighbour principle, which supposes that each output demand centre is allocated to its nearest supply centre (facility) using Euclidcan space (i.e. on a plane and in a straight line) or any existing road or rail network. There are two broad categories of location-allocation models depending on what objectives are set;

1. Minimum distance models ensure equiryof access by minimising travel distance for the whole population within the system such that the disparity in travel distance between all demand points (population units) in the whole system is minimised.

2. Maximum attendance models gurantee maximum profit (usage) for the facilities by ensuring that facilities are located as close as possible to polution densitics.

In either case, it is possible to generate three types of outputs :

1. A graphical representation of the location-allocation results showing demand points (population centres) allocated to each supply point (animal health facility).

2. A table of statistics of the travelled stances (costs) for each of the facilities based on the travel distances (Costs) of each of the demand unit (population) allocated to each supply points (facility). the unit of the travel cost can either be in kilometers of converted into time or monetray units.

3. A table of statistics of the proportion of the total population alocated to each facility within any specified distance ring either in percentage or in absolute figures.

In most developing countries for instance, goverment veterinary, facilities, especially clinics are located in regional headquarters based on existing political administrative structures. In such cases, location-allocation models can be used to produce information on the absolute population served (allocated) by each facility (e.g. clinic), as well as compute the mean travel stances (travel costs) for each member of the population served by the facilities. Such information will permit comparison of equity of access for the various population (comand) centres as they utilise their nearest veterinary facilities. More rational policy decisions can therefore be taken to reduce inequity to populations with higher travel costs through relocation of existing facilities or increasing number of facilitsies and personnel.

By manipulating the proportion of population allocation by the model, to the various facilities, usin area-specific-socio-economic coefficients as well as other attributes such as the capacity of the faciliti and types of personnel and services on offer (vetterinary, technician or paraveterinary) distibution diseases, cost benefit considerations, average earnings, practice visibility indices, optimum meanin levels, pollution indices (etc). will permit a wide range of analysis using the model. Preliminary results on-going work have shown that Location- Allocation models can be thus be adapted for use to he determine the optimum location for veterinary facilities making them more accessible especially to po and rural farmers (Odeyemi 1997). The model has also been used in determining the viability of existin facilities, so that decisions to support non-viable facilities for poorer communities could be taken in more informed way.

With such information available, resource needs, including naming levels could be better ascertain by the veterinary authorities. while veternarians who would wish to setup private practices have a mea of establishing the best location for viable practices. On-going work has equally shown the ability these models to permit the economic evaluation of disease control programmes by providing an insig into their potential uptake and hence the viability and sustainability of the disease control initiative Prelimianary evidance suggests that the model can also be used in the assesment of the environme impact of some animal production and health policies.

Constraints And Conclusions

The major aim of the model is to provide a means of evaluating animal production and hea initiatives being presented to any population in times of levels of uptake, equity of access, cost-bene consideration as well as issues relating to the viability and sustainability of services provided. Through ability to bring about a more rational policy decision making process, the outputs of the model, directly and positevely impact upon the ability of the various organs of delivery of livestock producti production and health services to provide a more efficient service. This in turn will result in the enhancem of the productive capacity of the target communities and contribute to sustainable development a poverty alleviation.

In the past, location-allocation models were tools for the specialists and written for other industri Current adaptation means in effect that in the future, more individuals would be able to use them, and t models are made more specific, easy to use, affordable and readily available for use by institutions delivery of animal health services in developing countries. However, prevailing diversities in the producti systems both between and within developing countries, coupled with the absence of reliablic data disease distribution, livestock dynamics and other socioeconomic and demographic factors emerged major constraints both to the development and the uptake of location-allocation modelling of anim health delivery services (Odeyemi 1996,1997).

While the technology and the expertise to develop the software is now available as reflected in going work, the accuracy and efficiency of the models will depend on the quality of data used. A ma assumption therefore is that such quality data would be available in a useable format, a situation fou not to be. In some cases, there even appears to be a reluctance by in-country institutions to allow d collection by researchers. Another major assumption presupposes that target country institutions wo have computer facilities required to run the software. Since the software is developed for use on sim personal computers, the initial financial outlay with regards to equipment its going to be very low within the reach of most target country institutions. Furthermore, one takes for granted that target count and other beneficiaries would use the product developed. For a lot of the developing countries howe decisions relating to resource allocation have continued to be based more on political expendienc rather than efficiency considerations. The risks posed by the assumptions relating to data quality and up take, hopefully can be averted by ensuring detailed area - specific field studies and effective and extensive dissemination exercises.

Potential application of the model include the planning, budgeting and monitoring of uptake and socio-economic benefits of diseases control programmes, determining viability and sustainability of government and private clinics, relocation alternatives for facilities as in restructuring, evaluating issues of equity of access as well as the determination of manning levels and manpower projections for the veterinary profession in a country (Odeyemi 1997). There is also evidence that the software could be used in the evaluation of the environment impact of livestock policies, an attribute which could prove useful in the conservation of the environment.

In the light of the above, there is clearly a great scope for Location-allocation modelling in the animal health delivery systems of developng and indeed developed countries. Prevailing diversities however suggest the need for detailed area specific studies as well as cross- country comparative studies to ensure that the predictions and decisions made using results of the model are accurate. In this wise, there is a need for co-operation and co-ordination between the veterinary professions of the various countries in the sub-region, especially in the area of data collection and management as well as capacity building in the development of policy research capabilities in their veterinary institutions.

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