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dissertation entitled

IMPACTS OF TSETSE CONTROL ON
MIGRATION AND CAPITAL ACCUMULATION:
ZAMBEZI VALLEY, ZIMBABWE

presented by

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has been accepted towards fulfillment
of the requirements for

Ph.D degree in Ag. Economics

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Date March 22, 1999

IMPACTS OF TSETSE CONTROL ON MIGRATION AND CAPITAL ACCUMULATION: ZAMBEZI VALLEY, ZIMBABWE

By

Jones Govereh

A DISSERTATION

Submitted to
Michigan State University
in partial fulfilment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics

1999

ABSTRACT

IMPACTS OF TSETSE CONTROL ON MIGRATION AND CAPITAL ACCUMULATION: ZAMBEZI VALLEY, ZIMBABWE

By

Jones Govereh

Tsetse control is ordinarily considered as simultaneously responsible for motivating household emigration from those districts bordering the tsetse cleared front as well as household immigration into cleared areas. The direct contribution of tsetse control to the process of internal migration in Zimbabwe, holding constant the historical imbalance in land access, regional differences in the development of infrastructure services and markets for commercial enterprises, is unknown. This study modeled annual growth in immigration at the village level and obtained settler's reasons for emigrating from their original settlements. The direct and indirect contributions of tsetse and trypanosomosis controls to livestock adoption in tsetse cleared areas is also not well understood. The study modeled growth in livestock adoption at the village level and investigated whether adoption began with or was accelerated by tsetse control. In addition, a production function model evaluated the effects of animal traction use on farm level factor productivity. Finally, the study also analyzed the distribution, extent and determinants of settler wealth accumulation and established the relative success of settlers.

This study was conducted in Gokwe North District, Zimbabwe in 1996. The survey was conducted in three cluster sites: an early cleared (1965 - 1976) area; mid-period controlled (1978 - 1987) area; and a recently cleared (1982 - 1994) area. All sites had

uniform drainage, soil and vegetation characteristics. Within each cluster, two wards were selected and in each ward, two villages were selected based on access to infrastructure services. A random sample of 40 households was selected from each village population.

Historical and regional land distribution patterns were responsible for household emigration from other districts contiguous and non-contiguous to Gokwe North. The relative unavailability of economic farming opportunities in old and well established areas led to emigration of young and growing families. The relatively unsettled alluvial plains of Gokwe North made it an attractive destination for immigrants whether there was or there as no tsetse flies. While tsetse control did not affect emigration, tsetse control directly affected immigration of households who moved into Gokwe North with livestock. The introduction of cattle and donkeys in Gokwe North was partly due to trypanosomosis control and in-migration. The pathways towards improved productivity were different between hand tillers, draft owners and draft renters. Use of animal traction enabled households to utilize additional amounts of land and labor. Wealth accumulation was influenced by the life cycle phenomenon as predicted in theory but was unexpectedly not impacted by the length of residential tenure. The presence of tsetse flies eliminated the premiums associated with early arrival. Early arrival after tsetse control was the best timing for establishing residence.

DEDICATION

This study is dedicated to all those whom I love from the bottom of my heart
most of all, my parents.
I thank you for the love that you always have had for me.
I give that love to you in return.
I miss you.

Rest In Peace.

ACKNOWLEDGMENTS

I give thanks and praises to the Almighty for her continued blessings. Thank you to those rural villagers and professors alike. I benefitted immensely from the assistance of many people, in particular, I am indebted to Dr. Allan Schmid my academic advisor and dissertation committee chair, Dr. Brent Swallow my field supervisor and my other committee members, Dr. Tom Reardon, Dr. Thom Jayne and Dr. Warren Samuels. Their counsel and support in my academic development is greatly appreciated. They are the reason I am where I am today.

Special thanks to Dr Rob Eley for administering over the award of my research fellowship at International Livestock Research Institute. His unwavering encouragement and personal development is appreciated. The field research on which this study is based was primarily financed by the International Fund for Agricultural Development through a Technical Assistance Grant to the International Livestock Research Institute. In Zimbabwe, the research was generously supported by the Tsetse and Trypanosomosis Control Branch of the Department of Veterinary Services (TTCB), the Regional Tsetse and Trypanosomosis Control Programme (RTTCP) and the Department of Agricultural Economics at the University of Zimbabwe (UZim). Thanks to the staff at TTCB and RTTCP in Harare and Gokwe. The author is grateful for information, assistance and advice provided in Zimbabwe by V. Chadenga, W. Shereni, R. Connor, M. Doran, R.

Mabeza-Chimedza and K. Muir-Lereshe, at the International Livestock Research Institute by R. Reid, B. Perry, and G. d'Ieteren.

Success in survey work is owed to the diligent work of field assistants: Peter Mureveri; Reason Majoto; Journey Sithole; Jabulani Mbano; Jane Motsi; Munyanyu Ngwenya; Gorosi Chikubwe; Killian Farikayi; Douglas Machau Mudukuti; Edna Siziba; Moses Muzanago and Svinurai Makoni. Thanks to the Sithole family for hosting me. I am also grateful for the help provided in data entry and cleaning by Florence and Simba Chimedza, Nester Chitepo and Lorraine. The research assistants handled their business well.

Finally, I owe a sincere debt to my wife, Annah Gasseler my daughter Shingi and son Tatenda. Keep your heads up. Thank you family for being my greatest inspiration. Everyone whom I forgot, you know I thank you.

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CHAPTER 1: TSETSE, TRYPANOSOMOSIS AND AGRICULTURAL DEVELOPMENT

Trypanosomosis is a constraint to rural development. The rationale for tsetse and trypanosomosis control is to develop the rural economy of affected areas by reducing the impact and constraints which trypanosomosis pose on crop and livestock production. Tsetse and trypanosomosis controls reduce diseases risk to livestock and people and indirectly boosts agricultural production / incomes, ultimately providing a feasible chance for rural villagers to accumulate wealth.

1.1 Tsetse and Trypanosome Species

In Zimbabwe, the main species of tsetse were *G. morsitans submorsitans, G. pallidipes* and *G. austeni*. The two species common in the Zambezi Valley were, *G. pallidipes* and *G. morsitans submorsitans*. The real source of the disease problem is a one-celled parasite known as a trypanosome. The tsetse fly is only the carrier, or vector of the parasite; the bite of a fly not infected with trypanosomes is not harmful. There are different trypanosomes present in Zambezi Valley. There is a human trypanosome called *Trypanosome rhodesiense* but it is rare and occurs in isolated locations along the Zambezi Valley.

In Zimbabwe, the problem parasites are those which affect livestock. There are three species of trypanosomes that affect cattle and other domestic animals. These are *T.brucei*, *T.congolense* and *T.vivax*. Each tsetse species is a good vector for particular trypanosome specie. The *G. m. submorsitans* are good vectors for *T.vivax* and *T.congolense*. The *T. brucei* have good vectors in *G.pallidipes* but infection rates are below 1% (Leak, 1996). The infection rates of *T.vivax* increase when the major hosts are bovines. On the other hand, an increase in infection rates of *T.congolense* occurs when the major hosts are suids.

1.2 Tsetse and Trypanosomosis Control Profiles

Zimbabwe has one of the longest and most continuous histories of tsetse and trypanosomosis control in Africa. Systematic tsetse control began as early as 1919 and drug therapy began soon after the discovery of the trypanocidal drugs in the early 1950s. Figure 1 is a time line of the techniques used for tsetse and trypanosomosis control in Zimbabwe.

1.2.1 Tsetse Control

Vector control measures dominated the approach to control trypanosomosis until the discovery of dimidium bromide compound in the early 50s (Connor, 1989). In Zimbabwe, tsetse control measures began as early as 1919. At that time, wholesale game elimination and bush clearing were the main forms of tsetse control. This went on until the discovery and development of pesticide science and application methods in the 60s (Shereni, 1991).

Bush clearing eliminated the tsetse habitat but vegetation loss along valleys destroyed the ecological resilience and this technique was discontinued quickly.

There was a public outcry locally and internationally against the shooting of wild animals. These concerns led to scaling down of these operations (Tsetse and Trypanosomosis Commission of Inquiry, 1954). Game elimination continued through the 1960s selectively and systematically along the tsetse front. Researchers first identified the preferred hosts of *G morsitans* and then targeted hosts for elimination. The identified host animals were kudu, bushbuck, warthog and bushpig. Elimination of these animals occurred within controlled hunting areas or hunting corridors. A game-hunting corridor had a game fence on one side and a cattle fence on the other side. The game fence prevented wild animals from moving into hunting areas while the cattle fence prevented cattle from moving into hunting areas. Selective hunting of wild animals reduced tsetse blood meals and starved off tsetse flies in the hunting corridors. The process was slow and positive results came after a few years (Coulman, personal communication). Pesticide application increased subsequent to the decline in bush clearing and hunting. Ground spraying of DDT began in the 60s and was the main method of control until the 80s. There were intermittent aerial spraying operations during the same period. Control operations where disrupted by the liberation war and some previously cleared areas, for example, part of Zambezi Valley Area, where re-infested.

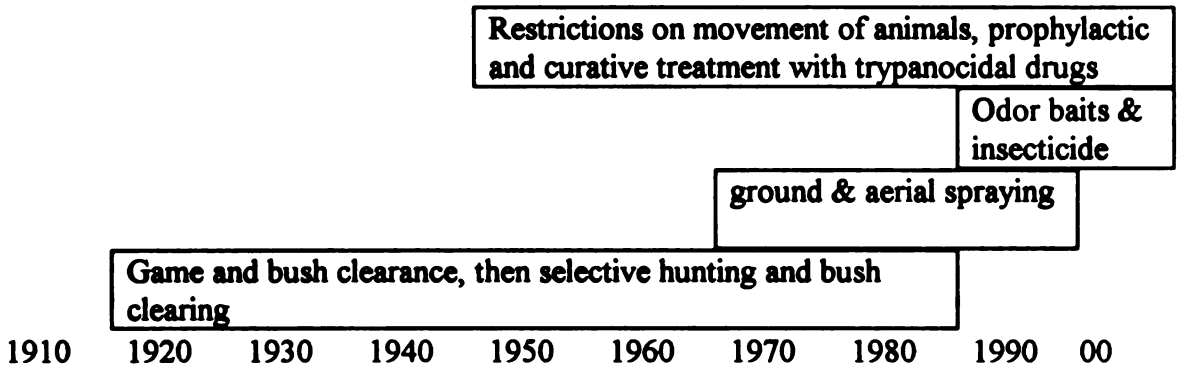

Figure 1. Time line of tsetse and trypanosomosis control techniques used in Zimbabwe 1910 - 1999
Source: Annual Reports, Tsetse and Trypanosomosis Control Branch (TTCB) 1960 - 95

Following national independence, tsetse control progressed through aerial and ground spraying. Most recently, odor baits and insecticide application techniques have been the main methods of vector control. Odor-bait techniques -- targets, pourons -- have become the main techniques used to control tsetse since the mid-1980s (Shereni, 1991; Connor, 1989). The odor-bait techniques are considered to be cost-effective (Barrett, 1997) and to have minimal direct environmental impacts (Grant, 1998). These technologies have helped push back the tsetse frontier and also act as barriers against re-invasion.

While much of northern and southern Zimbabwe is climatically suitable for tsetse, today only small pockets of tsetse remain in the north and northwest areas of the country. The tsetse population has been gradually eliminated from large parts of the country as control operations have systematically pushed the tsetse front further north and east. This gradual

expansion of the tsetse-free area provides an opportunity to evaluate the sequence of impacts that occur after tsetse control.

1.2.2 Disease Control

The Department of Veterinary Services monitor the incidence of trypanosomosis cases in domestic livestock. Trypanosomosis control measures are both preventative and curative. As early as 1953, treatments were prescribed to all livestock potentially exposed to disease risk (Connor, 1989). Administering of treatment occurred in central places and every communal farmer had to participate. To reduce chances of re-infection, treatment was administered to all the herds at the same time. The disease can spread from one animal to another whenever tsetse flies are present.

The standard policy was to administer prophylactics (Samorin) every 3-4 month depending on the degree of tsetse challenge. After diagnosis, treatment was given to all positive cases. Treatments were administered before and after tsetse control. Whenever the demand for treatment over stretched the capacity of the Department of Veterinary Services, it was economic to bring in vector control so as to reduce the need to procure and administer drugs. Chadenga (1994) argues that drug use was effective when the vector was eliminated or reduced to a low level. Treatments were suspending during vector control in order to evaluation the effectiveness of tsetse control operations.

Monitoring the incidence of trypanosomosis continued after tsetse control in order to assess the degree of re-infestation.

1.2.3 Regulating Livestock Movements

The general policy of the Department of Veterinary Services was to prohibit domestic livestock presence in areas with a high degree of tsetse challenge. Free movement of livestock in and out of fly country increased the probability of spreading the disease in fly-free areas and increased the demand for treatments. Besides the risk of spreading disease, domestic livestock movement restrictions prejudiced the success of hunting operations.

Despite the disease risks and fines, immigrants relentlessly brought in cattle and other livestock (Connor, 1989). Farmers were capable of maintaining livestock under disease risk through grazing management strategies. Regulating stock movements helped in keeping the disease at bay.

1.3 Impacts of Tsetse and Trypanosomosis Controls

1.3.1 Statement of Problem

The majority of studies on the impacts of tsetse presence on rural development, including traditional studies by Ford (1971) and Jordan (1986) focused on how the tsetse challenge inhibited human settlement and how animal diseases made these areas unattractive for

agriculture led settlement. Proponents for tsetse and trypanosomosis control in Zimbabwe argue that the presence of vector and disease challenges is a major constraint to livestock production (Chadenga 1994) and retards rural development (Connor 1989).

In Zimbabwe, it is not well established whether the presence of tsetse flies impedes immigration of families from less agriculturally endowed areas bordering the tsetse frontier. Yet tsetse flies and trypanosomosis controls are singled out as the main force behind the uncontrolled influx of immigrants and livestock into cleared areas. The contribution of other factors in attracting immigrants in cleared areas is unknown. One view is that tsetse control eliminates the human disease threat that keep people away from infested areas. A second view is that the construction of access roads by tsetse control gangs makes the previously remote tsetse-infested areas accessible to immigrants. A third view is that since the rise in world cotton lint prices in the 1960s, cotton became an attractive cash crop. Areas in Gokwe District with alluvial soils were a primary target for the *"white gold rush"* Lovemore (1997).

Part of the problem is that most attention is focused on the inflow of immigrants into Zambezi Valley while no connections are made to address why emigration occurs in other Communal Areas (CA). Young families who cannot secure individual arable land in their original settlement areas spontaneously move to other areas where they can earn a

livelihood through farming. Well-established families also move in search of larger holdings to support their growing families.

What is at work is the process of out-migration from areas bordering Gokwe and in-migration into Gokwe. The impact on both in-migration and out-migration due to tsetse control but separate from other factors are unknown at present. In addition, the interaction effects of tsetse control with all other factors are also unknown. Part of the problem is to separate these effects.

Investment in animal disease control in agricultural frontier areas has potential to transform the food systems by enabling technological progress and a shift from subsistence towards specialized production and exchange. It is not clear what impact these investments had in cattle adoption in Gokwe North District. Conventional wisdom suggests that the introduction of cattle in previously tsetse-infested belts is associated with eradication of tsetse flies. The empirical evidence to refute or support such claims is scant. The problem is that merely clearing an area of tsetse flies does not guarantee farmer adoption of cattle, especially when credit markets for cattle are non-existent. In addition, the impact of other factors, including farmer-to-farmer extension, access to curative drugs for trypanosomosis and the incentives or disincentives for commercialized production, are not articulated in current debates.

The extent to which animal traction affects farm productivity in this environment has not been clearly studied. In particular, no study has distinguished the impacts of cattle ownership versus hiring custom service on factor productivity. The problem is that ownership of animal traction is highly skewed and improving access to traction services cannot be completely addressed through extending ownership. If farmers who own animal traction resources are not more productive than farmers who merely hire a custom service, a minimum cost strategy may be to improve access to the traction rental market.

The role that investments towards an enabling environment play in socioeconomic mobility of settlers has previously been neglected. If a presence of high tsetse challenge is a constraint to rural development as suggested by proponents of tsetse control, the socioeconomic mobility of settlers would be inhibited without than with tsetse and trypanosomosis control. Traditionally, pioneers to a settlement frontier are expected to be relatively wealthy because of a long residential tenure. However, when faced with disease risk and limited agricultural opportunities, the early arrival premium may be non-existent. Instead, newcomers who settled after tsetse fly eradication may be progressing up the social ladder equally fast. The problem is that the early arrival premium cannot be taken as a given in these circumstances. Whether first settlers and newcomers have progressed equally over time is not known.

1.3.2 Purpose of Study

The purpose of this study was to generate understanding on the extent to which tsetse flies are a constraint to agriculturally led development. Such knowledge will help in the formulation of socioeconomic policies that direct the development of land settlements and mixed farming systems in tsetse cleared areas.

A good understanding of the motives for out-migration may help in planning alternative ways to reduce unwanted internal-immigration. Given the limited budget government operates with, it is critical to understand what public investments are required in order to attract additional private investment. An improved understanding of the sequencing of public and private investments is a pre-requisite in rural development in general and farming systems development in particular.

Animal traction technology has potential to improve smallholder farm productivity. This study identifies pathways that can stimulate adoption of this technology. Observing that adoption of animal traction will not be complete, the study analyzed the potential impact of improving the traction rental market access on partial factor productivity. An improved traction rental market may be a feasible short to medium term solution to ownership of traction animals and equipment in the long run.

New settlement frontiers have been perceived to provide a safety net to citizens who have failed to be absorbed into the labor force. This study will attempt to establish whether new agricultural frontiers provide an equitable opportunity for socioeconomic advancement to all settlers and whether voluntary- unassisted settlements can be tolerated as an equitable redistribution process.

1.3.3 Objectives

The general objective is to investigate the effects of tsetse control on human migration and livestock adoption and household socioeconomic mobility. The specific objectives are:

1. to identify why families choose to leave their previous residences and settle in agricultural frontier areas;
2. to quantify the impacts of tsetse control relative to other factors that attract migrants to frontier areas;
3. to measure the impact of tsetse control, immigration and commercial production enabling environment on the rate of cattle adoption per village over time and space;
4. to identify the differences in factor productivity between farmers who use and own animal traction and those farmers who do not own but hire animal traction services; and
5. to measure differences in wealth holding and socioeconomic mobility between different types of settlers.

1.3.4 Hypothesis

This study tested several hypotheses. These hypotheses are presented below in an alternate form. The hypotheses test relationships that I believe exist between tsetse and trypanosomosis controls and in-migration, livestock adoption and socioeconomic mobility.

1. The distribution of agricultural economic opportunities among the rural districts of Zimbabwe is in not uniform. I expect economic factors especially access to land rather than social ties to dominate motives for out-migration.
2. Tsetse and trypanosomosis controls positively contribute to making a site attractive for in-migration especially when immigrants are moving in together with their livestock. Everything else being the same, I expect immigrants to settle in areas controlled of tsetse and trypanosomosis first before choosing tsetse-infested areas.
3. The availability of infrastructure services including public transport, health and education services positively contributes to making a site attractive for in-migration. I expect immigrants to settle in villages with better infrastructure services first before they settle in relatively remote villages.
4. Tsetse and trypanosomosis controls allow livestock to thrive in areas they would have perished. Access to curative drugs could be sufficient for the introduction of cattle in tsetse-infested areas but both tsetse and trypanosomosis controls may be

essential for widespread adoption of livestock. Subject to access to drug therapy, I expect settlers to adopt cattle before active tsetse fly control.

5. There are cultural differences between indigenous and immigrant settlers in terms of livestock adoption. Pioneer settlers had relied primarily on manual tillage in their cropping systems. Cattle had an extremely limited farming role in their traditional way of life. As a result, I expect newcomer settlers to be an instrumental force in introducing mixed farming systems to tsetse cleared areas.

6. Access to animal traction services can be secured through custom hiring. A rental market enables non-owners to improve their resource productivity. Owing to excessive demand for custom service, not all those who need to hire these services get it in time. Everything else being the same, I expect owners of animal traction services to be much more productive than renters of animal traction service.

7. The presence of tsetse flies in a settlement area is viewed as an impediment to economic progress of settlers. Despite being the pioneers, settlers who move in before tsetse control do not gain much economically because of the adverse physical conditions in settlement areas. I expect the premium associated with settlement tenure to be insignificant prior to tsetse control but significant after tsetse control.

1.4 Dissertation Outline

The following chapter describes the research design adopted in this study and provides a general description of the study sites. This chapter highlights the key variables controlled in the study and describes the general population characteristics for which results from this study can be relevant.

Chapter 3 examines the factors that push and pull migration into the Zambezi Valley of Zimbabwe. Specifically, the impacts of tsetse and trypanosomosis controls are separated from other factors contributing to immigration into Gokwe North District. A model of the stock of migration is developed to study the effects on migration due to the interaction between tsetse control and other factors.

Chapter 4 presents an annual growth model of cattle adoption from 1965 to 1996 for 12 villages in Gokwe North. The role of tsetse control in both the introduction of cattle and the spread in cattle is evaluated. This chapter also examines the impact of animal traction on resource productivity and measures the differential impact of animal traction use between household who own and households who rent-in traction services.

Chapter 5 discusses the distribution and determinants of wealth among settlers. The sources of wealth considered are livestock, land improvements and farm equipment assets. Previous studies focussed on household wealth per se but in this study per capita wealth

holding is the dependent variable. Based on the evidence, the life cycle and settlement tenure hypotheses are examined. In addition, this chapter also evaluates socioeconomic mobility of household wealth. A sub-sample of households who settled before 1988 are the ones considered for this analysis. The livestock and equipment wealth position of the household in 1987 and 1996 are compared to examine the direction and extent of wealth mobility.

Chapter 6 provides a discussion of the results, summarizes the conclusions and identifies issues that require further research.

CHAPTER 2: RESEARCH DESIGN AND INSTRUMENTS

2.0 Introduction

In this chapter, a description of general physical conditions in study sites is provided. The study design, the sampling approach and the instruments used to implement the study are also discussed in this chapter.

2.1 Study Location and Physical Characteristics

In order to focus attention on the effects of tsetse control on migration and livestock adoption, the study was designed to control for some of the factors that vary across space, especially district government, soil type and rainfall. The study was confined to Gokwe North District. Gokwe North is located in north-western Zimbabwe. Almost all the district is in the Zambezi Valley and it is climatically suited for tsetse fly habitat. Gokwe North District was an ideal site because it had a 25-year history of active tsetse and trypanosomosis controls. Parts of the district were actively cleared of tsetse since the mid-1960s, while other parts were cleared as recently as 1995. The gradual expansion of the tsetse-free area in Gokwe North provides an opportunity to evaluate the sequence of impacts that occur after tsetse control. Study villages were purposively selected to represent different lengths of time since tsetse control.

Sites were selected from a uniform land class unit. The land class unit had uniform parent rock material, vegetation characteristics and drainage patterns (Anderson, 1993). Uniformity of land class unit was important in order to make the impacts of tsetse control on the farming systems across villages comparable. This land class unit selected was along major river systems (Ume, Sessame, Sengwa and Gunguwe) where settlement and agricultural production were first established and most concentrated in the Zambezi Valley. Land in those drainage areas is comprised of flood plains and terraces of the larger river systems with alluvial and argillaceous parent material. Soils are moderately well drained, moderately shallow, sandy clay loam or clay. These soils have high agricultural potential and thus have been an early destination area for immigrants interested in crop production (Anderson et al 1993). The dominant vegetative characteristic under this land unit is the mature mopane or miombo woodlands. The vegetation is dense woodland in unsettled areas but wooded grasslands in sites with active settlement.

2.2 Survey Design

The survey design featured two control variables (1) the period of time since control and (2) the degree of access to infrastructure services. The design chose to control these variables in order to measure their effect on performance variables.

The study chose three levels to represent the tsetse control gradient: early clearance (1970 - 1976); mid clearance (1980 - 1986); and late or recent clearance (1984 - 1990). This

stratification gave a tsetse control gradient with three cluster sites. The period of time since control was expected to have profound effects on the pace of in-migration, livestock adoption and farming systems change.

Access to infrastructure and markets were factors that attracted immigrants and affected the development of farming systems. I expected immigrants to prefer areas with better infrastructure services, for example, road network, schools and clinics. I also expected settlers in villages with better infrastructure to have a commercial oriented production system, for example, a high percentage of cropped area under cotton. The infrastructure parameter had two levels: villages with the best access to infrastructure and villages with the poorest access to infrastructure services as of 1996.

In summary, there were two design factors, one with three levels and the other with two levels. The design gave six combinations of control period and access to infrastructure: (1) early clearance with good infrastructure; (2) early clearance with poor infrastructure; (3) medium clearance with good infrastructure; (4) medium clearance with poor infrastructure; (5) late clearance with good infrastructure; (6) and late clearance with poor infrastructure. Selecting two wards in each cluster gave each combination a replication which brought the total study sites to 12. Figure 2.1 shows the three levels of the time of tsetse control gradient, the replication at ward level and two levels of infrastructure gradient.

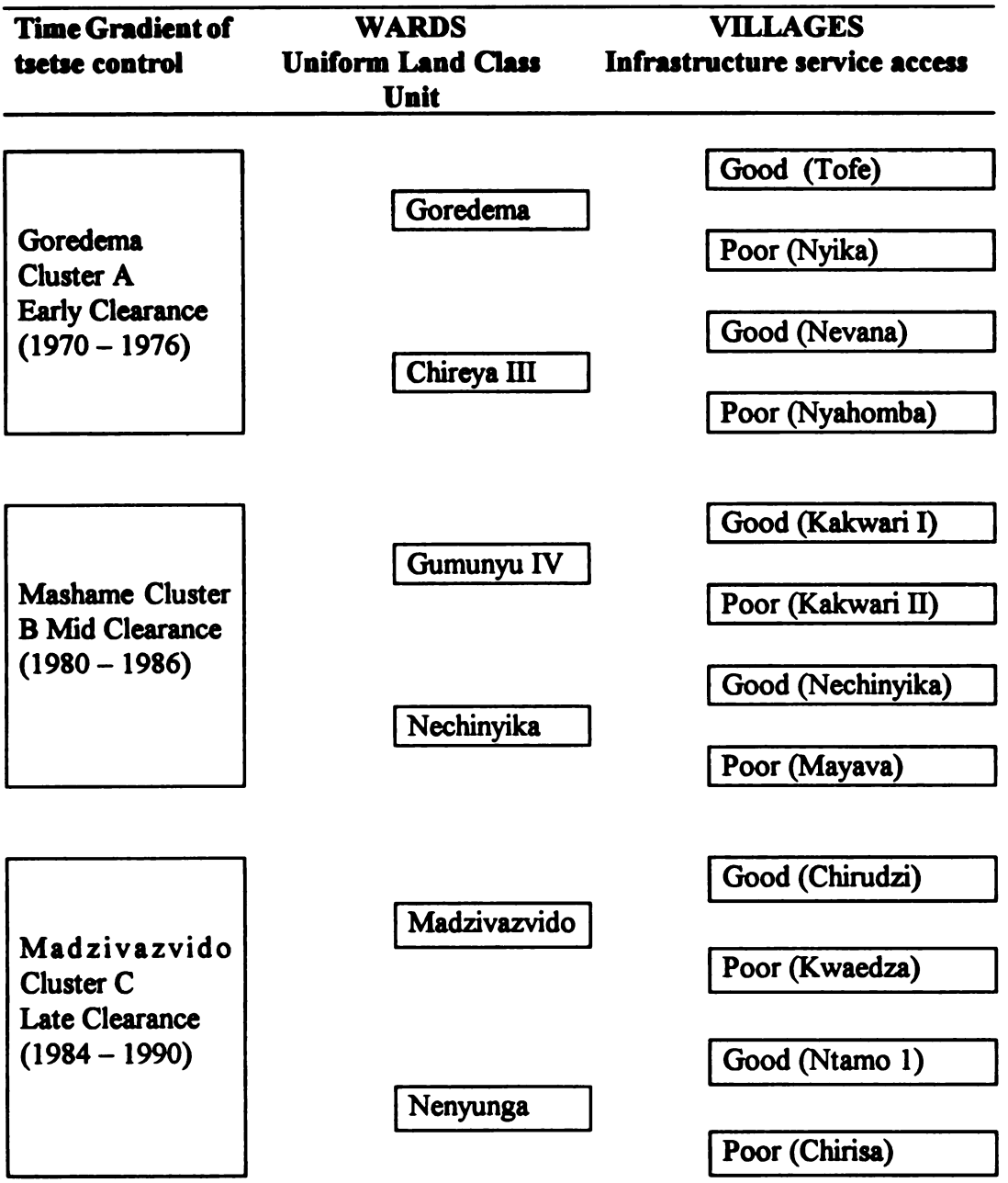

Figure 2.1 Sample Stratification in the Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Survey

2.3 Sites and Household Selection

A five-stage stratified sampling procedure was adopted to select study sites within Gokwe North. The sample stratification is shown in Figure 2.1. The first stage involved the purposive selection of the three cluster areas representing a gradient of time since tsetse control. Once the cluster areas were identified, sites within a similar land class unit across the gradient were targeted for further selection. During the second stage of sampling, two wards (local government units) within the same land classification were selected from each cluster area. Selection of two wards gave the study an opportunity to identify any differences in local administration that could have affected migration and settlement. Two wards also improved representativeness within the cluster. During the third stage, two villages were purposively selected from each ward: one village had the best access to services and the other had the poorest access to services at that time. Villages, also referred to as VIDCOs or village development committee areas, are the smallest local administrative unit. Important services targeted in the selection criteria included access to public transport, primary schools and health centers. During the fourth stage, a random sample of households was drawn from the population of each selected village.

The study randomly selected a sample of forty households from a village population list. I used registers of village leaders and extension workers to compile a village population list. I conducted random selection of households during village meetings that village leaders and other villagers attended. I purposively included village heads in the sample in order to

guarantee popular participation but I excluded them from the analysis. As leaders, village heads exerted much influence, and made a difference between success and failure of the study.

2.4 Tsetse and Trypanosomosis Control Operations in Cluster Sites

The study selected three cluster sites along the tsetse control gradient. Cluster A is a site known as Goredema, Cluster B is Mashame and Cluster C is Madzivazvido. In Goredema, active tsetse and trypanosomosis controls started around 1965. Tsetse control started with selective game hunting. Ground spraying of tsetse with DDT commenced in 1970 until 1976. Although there were positive infection cases in Goredema from 1980 to 1983, the disease risk was low.

In Mashame, strategies used to control tsetse were selective game hunting in the 70s, ground spraying from 1980 to 1986 and use of odor baits in 1990. Odor baits were planted along the district northern border to provide a barrier against re-invasion. Trypanosomosis control efforts started around 1983 and continued during and after tsetse control.

In Madzivazvido, control operations included use of aerial spraying from 1983 to 1984. Ground spraying followed thereafter in 1986/87 in areas where tsetse continued to present problems. In Madzivazvido, planting of odor baits occurred in 1988 but were removed in 1990. Trypanosomosis control efforts started before 1983 and continued well after tsetse control campaigns.

2.5 Survey Instruments

I used questionnaires to collect household-level data. The study had four questionnaires, hence multiple visits were done. I supplemented household survey data with structured interviews with local administrative and traditional leaders, civil servants and business entrepreneurs.

The first questionnaire focused on effects of tsetse controls on livestock adoption and human migration. This questionnaire addressed issues pertaining to in-and-out migration, and how tsetse control affected the numbers and species of livestock kept by existing residents and that new immigrants brought with them. Interviews on this questionnaire started in March until May, 1996.

The second questionnaire addressed the indirect impacts of tsetse control on crop production. The questionnaire focused on assessing differences and similarities in crop production among existing residents and immigrants. Household visits happened from June to July, 1996.

The third questionnaire focused on two issues. The first focus was on soliciting perceptions about the incidence of the utility and disutility of tsetse control. The second focus of the questionnaire determined the conditions under which households had access to land-based resources. Interviews started in August until October 1996.

The fourth and final questionnaire addressed issues pertaining to households' aspirations and desires to expand and improve their arable and residential plots. Household visits were from November 1996 to January 1997.

I hired enumerators to administer these questionnaires. Enumerators were high school graduates and were resident in the village they worked. I shared the responsibility for selecting enumerators with village leaders. Village leaders and agricultural extension workers participated in the selection so as to increase the chances of respondent cooperation during interviews. By engaging local leaders in this process, they accepted the responsibility of solve potential problems between enumerators and respondents. There was one case of enumerator turnover during the survey.

CHAPTER 3: THE IMPACTS OF TSETSE CONTROL ON IMMIGRATION

3.0 Introduction

Migration is one of the most important factors shaping processes of change and development in agricultural frontier areas. In this chapter, the factors that push people from older settled areas and pull migration into the Zambezi Valley of Zimbabwe are examined. Specifically, the impacts of tsetse and trypanosomosis control from other factors contributing to immigration into the Gokwe North District of the Zambezi Valley are separated. A model of the stock of migration was developed and estimated using survey data collected from 482 households in 12 villages having different experiences with tsetse control. The results suggest that emigration from source areas is primarily motivated by desires to gain greater access to agricultural land. Although it started before tsetse control was undertaken, immigration into destination areas was accelerated by public investments in tsetse control. The establishment of roads and markets also had significant impacts on the rate of immigration.

This chapter seeks to accomplish two objectives. The first objective is to understand why families choose to leave their previous residences and settle in agricultural frontier areas. The second objective is to quantify the impacts of tsetse control relative to other factors that attract migrants to frontier areas.

3.1 Modeling Immigration Stocks and Flows

3.1.1 Background and Relevant Literature

Economic models of migration assume that potential migrants will move from one location to another in order to maximize the expected net present value of their earnings, subject to budget constraints and the costs associated with migration. An implication of this individual behavior is that there will be net immigration into areas with high expected earning potential and net emigration from areas with low expected earning potential. The Hecksher, Ohlin and Samuelson trade model suggests that a region with relatively abundant labor will export that factor to a labor-deficit region until the wage rate equalizes across regions. Land-abundant areas with low population densities and labor-abundant areas with high population densities stand to mutually benefit from the flow of immigrants to the land-abundant area (Borjas 1988).

There are at least four additional factors that have been shown to affect migration patterns: (1) the monetary and psychological costs associated with migration; (2) the quantity and quality of the public amenities available in both source and destination areas (Diamond and Tolley 1982); (3) the institutional and legal procedures affecting migration (Pessino, 1989); and (4) civil unrest and war. High monetary and / or psychological costs associated with migration will reduce expected net earnings and utility in potential destination areas and potential source areas.

Public amenities that are purely consumptive can also affect the comparison of source and destination areas; potential migrants may be willing to accept lower earnings to increase their access to superior consumption amenities (Carlino & Mills, 1987; Knapp & Graves, 1989; Mathur, 1988). Public amenities that are more productive – for example, tsetse control, markets, roads, communication infrastructure – will affect migration through expected earnings. Here the study hypothesizes that the main impact of productive amenities like tsetse control and roads is to raise earning potential and thus make the area more attractive to potential migrants. Tsetse control will affect expected earnings for households that currently own livestock, for households that intend to own livestock, or for households that intend to employ livestock in their farming operations. *A priori*, however, there is no clear causal relationship between immigration, tsetse control and the establishment of other public amenities. There are at least four non-exclusive possibilities: 1) Public amenities may be developed in anticipation of immigration and the prior location of public amenities may make an area attractive for new immigrants; 2) The agencies that plan the development of public amenities may respond to the presence of large numbers of new immigrants; 3) The agencies that plan tsetse control may respond to the needs of large numbers of new immigrants with infected animals; and 4) Tsetse control may be a keystone public investment that leads both private migration and the public development of other public amenities.

War can affect migration in several ways. What is commonly observed is the involuntary displacement of war victims who are resettled outside battle-fronts. Rohrbach's study of the

determinants of growth in smallholder maize production in Zimbabwe found lower than average growth of smallholder farmers (2.5% per annum) during the peak of violence (1976 to 1979). As the war wound down in late 1979, households, especially young ones, "took advantage of this period of flux to move away from their parents and establish independent farms ... voluntary resettlement was substantially greater than that made necessary by the war" (Rohrbach 1989). The growth in maize production, dubbed Zimbabwe's Green Revolution by Eicher and Rukuni (1995), was due to an expansion of total maize acreage as abandoned land, new land and part of the former grazing land were planted with maize (Rohrbach 1989).

Rural instability associated with war increases mobility and adaptation costs. During the civil war in Zimbabwe, the provision of all public amenities including tsetse and trypanosomosis control was hindered by the increasing security risk for public officers. Thus we expected a large increase in immigration into the Zambezi Valley after 1979 due to the transition from war to peace.

Prior to this study it was proposed that sequential migration – movement from a source area to a destination area and then on to another destination area – was an important phenomenon in the Zambezi Valley of Zimbabwe. Pessino (1989) argues that the more sound the basis of information for the initial move, the lower the propensity for subsequent migration. In a study he conducted in Peru, Pessino found very little sequential migration. The cost of establishing

a new residential site and clearing land for cropping may have been the major disincentive. To avoid losses associated with the abandonment of such sites, immigrants invested a great deal of time gathering information about potential settlement sites from friends in those sites.

The conventional wisdom on internal rural migration in Zimbabwe is that tsetse control causes migration into the Zambezi Valley. Lovemore (1997) points to population growth in rural areas outside the tsetse belt as the cause of immigrant inflow to tsetse cleared areas. The Government of Zimbabwe does not have a clear-cut policy on spontaneous and unassisted internal migration. While the Government does not actively encourage voluntary internal migration, it does indirectly support migration through its policy of granting 5 hectares of arable land to new immigrant families. Immigrants are, however, perceived by the local media to be "looters" of land resources (The Herald, 4 May 1996) and contributors to leadership wrangles in local politics.

3.1.2 Foundations of Immigration Growth Model

Immigration into a particular area can be conceptualized as a stock variable. The stock of immigrants is the total number of immigrants in a particular village at a particular time. Here the study denotes the variable M_{it} as the cumulative number of immigrant families in a village i, at time t. For example, when $t = 1990$ and $i = 10$, M_{it} was 14. The number of immigrant families who settle in the village during a particular year is the flow of immigrants. The stock

and flow variables were determined by aggregating the responses immigrant settlers gave when asked "Which year did you establish you first settlement in this village?"

Empirical research on the determinants of migration involves estimation of an exponential equation with the stock of migrants as the dependent variable and independent variables such as time as exponents (Schutlz, 1982). The generalized form of an exponential function is given by equation (3.1):

$$y = ab^{ct} \tag{3.1}$$

where a and c are "compressing" and "extending" agents, respectively.

With base e in exponential function, the function of cumulative stock of migrant settlers becomes equation (3.2),

$$M_{it} = Ae^{rt+u} \tag{3.2}$$

Where r is a constant - the instantaneous rate of growth of migrants in the village at any given time and u is the random error term. In logarithmic form, the model is given by equation (3.3),

$$\ln M_{it} = \ln A + rt+u. \tag{3.3}$$

The variables that either compress or extend this function are described in the following subsection.

3.1.3 Specification of the Empirical Model

The following variables were included in the model as independent variables for explaining the stock of migrants in each village per year. Some of the other variables that might also be important, e.g. soil fertility and potential yields, were held constant by the design of the sample selection procedure.

Tsetse Control: This variable measures the periods with tsetse control, denoted by a value of one, and periods without tsetse control, denoted by a value zero. A continuous measure of the prevalence of both tsetse and trypanosomosis was hard to capture for each site. I expected that the growth of the immigrant population would be higher during periods of tsetse control than during periods without tsetse control. If immigrants anticipated tsetse control in a particular area, the rate of immigration into that area could have been affected before active control began. However, if immigrants were only reacting to actual control, the flow would be significantly affected only after tsetse control. It is also possible that immigrants were reacting to disease control in anticipation of disease control. Tsetse control is a productive public amenity that has the potential to increase livestock productivity, and through draft power, the crop productivity for individual farmers.

Cotton / maize price ratio: The ratio of the real price of cotton relative to the real price of maize (1970 = 100) for maize and cotton traded in Zimbabwe's central market was included in the model. This variable is a proxy for expected earning potential in both destination and

source areas. In both the source and destination areas, cotton is the main cash crop and maize is the main subsistence crop. Everything else equal, an increase in the cotton / maize price-ratio indicates an increase in potential earnings for food-secure households that produced cotton and enough maize to meet household subsistence requirements and a decrease in potential earnings for households that did not produce cotton and produced more maize than they consumed. A positive relationship between the price-ratio and the rate of migration into destination areas would imply that food-secure households moved in response to expectations of better opportunities to produce cotton, while a negative relationship would imply that food-insecure households moved in response to expectations of better opportunities to produce maize.

Access to Schools: This variable measures access to primary schools. When a school was accessible within an eight-kilometer radius, the variable was given a value of one, otherwise it was given a value of zero. The study expected migrants to be more attracted to areas with good access to schools. Eight kilometers is an estimate of the maximum distance that people might walk each way to a school, clinic or market and return home within the same day.

Access to Clinics: When a clinic was accessible within an eight-kilometer radius, this variable was given a value of one, otherwise it was given a value of zero. Migrants are expected to be more attracted to areas with good access to clinics.

Marketing Costs: This variable measures access to a central marketing depot; one denotes the presence of a marketing depot within 60 kilometers, zero indicates no marketing depot within 60 kilometers of the village. Better access to marketing depots reduces marketing costs through reductions in freight charges and creates greater market stability. The study expected immigrants to be more attracted to areas with better access to markets.

Transportation Costs: Roads and public transportation facilities make rural areas more accessible for settlement by migrants. The effect of a road is to reduce costs the costs associated with migration into an area as well as the costs of purchasing inputs and selling outputs. Areas with bus stations within a radius of eight kilometers were considered accessible and denoted by a value one; otherwise they were given a value of zero. The study expected migrants to be more attracted to areas with lower transportation costs.

Time Trend: The flow of migrants into villages was different at different times. The dependent variable and one of the independent variables, purchasing power, have trends. A time variable was included as an independent variable to account for the trend effect in the other variables. The study hypothesized that the growth rate of migrant settlers would be positive and accelerated by tsetse control.

The estimated immigration function is equation (3.4):

$$M_{it} = P_{it} e^{rT + aL_i + bY_j + cD_k} \quad (3.4)$$

where:

i the ward = 1,...,6; *t* the period = 1,...,35 years; *j* the amenity type = 1 (roads and transport), 2(markets), 3(schools), 4(clinics); and *k* experience with tsetse control (1 with and 0 without tsetse control)

M_{it} = the stock of immigrants in village i during year t
P_{it} = the earnings ratio
T = time trend
r = rate of instantaneous growth in immigration
a = percentage difference in immigration stock in different locations
L = ward location
b = percentage difference in immigration stock with and without access to amenity
Y= type of amenity
c = percentage difference in immigration stock with and without tsetse control
D= with and without tsetse control

3.2 Extent of Immigration in Study Sites

Of the 482 sample households in 1996, 43% were indigenous residents, 28% were second-generation immigrants and 29% were first-generation immigrants (Table 3.1). Significantly, all of the village heads were indigenous residents. Indigenous residents are households in which the parents of the household head grew up in the area and established their first homesteads in the study sites. Second-generation immigrants are households in which the parents of the household head immigrated into the area and established households. First generation immigrants are households that left earlier settlements outside of the study site to

establish new settlements in the study sites. The results presented in this chapter focus primarily on first-generation immigrants.

Table 3.1: Distribution of first and second generation immigrants and indigenous residents in Gokwe North, Zimbabwe, 1996

Household Group	No. households	% of Total
First generation immigrants	142	29
Second generation immigrants	133	28
Indigenous residents	207	43
Total sample	482	100
Village heads – indigenous residents	55	

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Gokwe North, Zimbabwe, 1996-97

Table 3.2 indicates the number of first-generation immigrants in each village and the time period during which they moved into the village. The results indicate relatively slow and steady immigration to the area between 1966 and 1980 when 18% of the first-generation immigrants moved to the area. Total immigration peaked between 1981 and 1985, that is, immediately after Zimbabwe achieved political independence after several years of civil war. Twenty-eight percent of the first-generation immigrants indicated that they moved to the area during that 5-year period. Immigration remained fairly high thereafter with 21% of first-generation immigrants arriving between 1986 and 1990 and another 21% arriving between 1991 and 1995.

Table 3.2: The Inflow of Immigrants into Villages 1965 - 1995, Gokwe North, Zimbabwe, 1996

	Period							
Village	<196	66-70	71-75	76-80	81-85	86-90	91-95	Total
Tofe	0	1	0	0	0	0	0	1
Goredema	3	3	0	1	5	1	1	14
Masvingo	0	1	2	8	6	1	3	21
Nyahomba	2	1	0	0	2	0	0	5
Kakwari I	0	1	1	1	8	0	3	14
Kakwari II	1	1	1	1	9	4	3	20
Nechinyika	1	0	1	0	2	4	1	9
Mayava	0	0	0	0	7	1	0	8
Chirudzi	0	0	0	0	1	6	7	14
Kwaedza	1	0	1	0	4	6	7	19
Ntamo	2	0	0	0	0	0	0	2
Chirisa	1	1	0	0	1	7	4	14
TOTAL	11	9	6	11	45	30	29	141

(Note: The shaded cells indicate periods of active tsetse control in each village.)
Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Zimbabwe, 1996-97

Table 3.3 presents information on the provinces from which people emigrated to Gokwe North. All but one of Zimbabwe'e eight provinces were source areas for migrants to Gokwe North. The exception, Manicaland, is on the eastern border and is the furthest province from Gokwe North District. Otherwise there does not appear to be a strong relationship between number of migrants and distance from source to destination. About 45% of the migrants

were from Masvingo Province, about 450 kilometers from Gokwe North, and another 45% were from Midlands Province, about 270 kilometers from Gokwe North.

Table 3.3: Provinces where Migrants Emigrated, Gokwe North, Zimbabwe, 1996

	No. of Immigrant Families From Each Province			
Settlement timing	Mashonaland	Matabeleland	Masvingo	Midlands
Before tsetse control	2	1	13	11
During tsetse control	4	3	23	17
After tsetse control	11	4	22	31
All time periods	17	8	58	59

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Zimbabwe, 1996-97

Table 3. 4 presents the reasons given by first-generation immigrants as to why they moved. Most moved voluntarily. Thirty-five percent said that they moved because their farms were too small,17% had no farms, and 26% said that the soils in their original locations were infertile and needed large inputs of fertilizer and manure.

Table 3.4: Reasons Why Migrants Choose to Emigrate From Their Areas of Origin Before, During and After Tsetse Control into Gokwe North, Zimbabwe, 1996

Reason for moving from original settlement	Before	During	After
	(Number in parenthesis is %)		
My arable plot was too small for my needs	10(38)	15(32)	25(4)
I did not have an arable plot of my own	4(15)	9(19)	11(17)
The soil had poor fertility	6(23)	15(32)	16(25)
I was forced to move by government	2(8)	1(2)	1(2)
The area was highly susceptible to droughts	0	2(4)	5(8)
It was difficult to get services	0	2(4)	0
I was running away from tsetse	1(4)	0	3(5)
I got married here	1(4)	0	0
I divorced and moved here	0	0	2(3)
I was running away from witchcraft	1(4)	0	0
I was accused of being a spy during the war	1(4)	3(7)	0
MISSING CASES	1	0	5
TOTAL SAMPLE	27(100%)	47(100%)	68(100%

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Zimbabwe, 1996-97.

A minority of households felt that they were forced to move. Four of the 141 households were evicted from original settlement. Two female-headed families moved back to their parents' villages after divorcing their husbands. Four households that immigrated before and during tsetse control were expelled from their former villages because they were accused of being spies during the war of liberation. Four more households migrated to tsetse controlled areas to escape tsetse flies.

Table 3. 5 shows the amount of sequential migration, distinguishing between immigrants who moved within the same village or ward in which they originally settled, and immigrants who moved between wards.

Table 3.5: Frequency of Sequential Migration Within and Between Wards Before, During and After Tsetse Control, Zimbabwe, 1996

Radius of sequential migration		**Before**	**During**	**After**
Within present ward	Yes	1(4)	0	3(5)
	No	26(96)	47(100)	64 (95)
	Total	27(100	47(100)	67(100)
Between wards	Yes	5 (23)	5 (11)	5(8)
	No	22(77)	42(89)	62(92)
	Total	27(100	47(100)	67(100)
Primary reason for moving				
Wanted more land		1	1	1
Poor relations with neighbours		0	0	1
Dispute in land ownership		1	0	4
Problem getting water for domestic use		0	0	2
Could not keep cattle due to tsetse		0	1	0
Wild animals caused havoc		0	1	0
Inadequate pasture land		1	1	0
Services were far away		0	1	0
Total		3	5	8

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Controls, Gokwe North, Zimbabwe, 1996-97

Of the 141 first-generation migrants, only four reported that they had moved within the same village or ward, while 15 reported that they had moved between wards within Gokwe North. Availability of land and disputes over available land were the main reasons given by respondents for their sequential migration. Most of the migration within ward occurred after tsetse control had been established in the ward area but most migration between occurred before tsetse control.

Table 3.6 shows the time period during which different types of public amenities were established in the study sites relative to when tsetse control occurred and the period of greatest immigration. Generally, the initiation of tsetse control predated public investments in infrastructure for villages in which tsetse control began before 1985.

In the four villages in which tsetse control began in 1985, tsetse control began in the mid-range of all public infrastructure. In general, most public amenities were in place before the period of greatest immigration.

The order in which amenities were established varied somewhat across villages. In the villages with the earliest tsetse control, most of the public amenities were established at about the same time, six to ten years after the initiation of tsetse control. This reflects the strong central planning approach to development adopted by the pre-independence government of Zimbabwe. Few amenities were established between 1972 and 1982,

probably due to the civil war that dominated events during that period. Since 1982, the pattern of development has been somewhat more haphazard. At the time of the survey, four of the villages had no clinics and two had no schools.

Table 3.6: Sequence of Establishing Services in Study Sites, Gokwe North, Zimbabwe, 1996

Village by Name	Year public amenity was established					Peak Flow of Migrants
	Clinic[a]	School[a]	Roads[b]	Market[c]	Clearance[d]	
Goredema	1972	1972	1972	1972	1966-75	1966-70
Tofe	1972	1972	1972	1972	1966-75	1981-85
Masvingo	1982	1972	1972	1982	1972-76	1976-80
Nyahomba	1982	1981	1987	1982	1972-76	1981-85
Kakwari I	1982	1972	1967	1992	1975-88	1981-85
Kakwari II	None	1987	1972	1992	1975-88	1981-85
Nechinyika	1983	1987	1967	1982	1981-88	1986-90
Mayava	None	None	1982	1992	1981-88	1981-85
Chirudzi	1987	1963	1993	1982	1976-94	1991-95
Kwaedza	None	None	1987	1982	1976-94	1991-95
Ntamo	1987	1963	1987	1982	1983-92	<1966
Chirisa	None	1994	1987	1982	1983-92	1986-90

[a] Clinics and schools are accessible within an 8-km radius[b] Primary roads open to buses and trucks [c] Marketing depots are within a 60 km radius [d] Years of active tsetse control
Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Zimbabwe, 1996-97

3.3 Relative Impacts of Tsetse Control on Immigration

The migration data discussed above were used to develop a variable measuring the stock of first-generation migrants in each village for each year (M_{itt}) between 1963 and 1995. The dependent variable had 396 observations, representing 33 periods in the 12 villages. Similar variables were specified for all of the explanatory variables presented above. All of the explanatory variables were included with interaction terms to allow for different effects before and after tsetse control.

The results presented in Table 3.7 show that the model has good overall explanatory power, explaining 68% of the variation in the stock of migrants. The strong F test shows the significance of the overall model. The results for each explanatory variable are discussed in turn hereafter.

Constant: The estimate of the constant shows the expected stock of first-generation immigrants prior to 1966 was 3.3. Across the 12 villages, this represents 28% of all first-generation immigrants in the villages at the time of the study.

Ward effects: Villages in the ward that had experienced tsetse control more recently had a higher proportion of immigrants than other villages prior to tsetse control. The preference for newer settlement frontiers suggests immmigrants anticipated control in the areas they

moved into. There were no systematic differences between the stock of immigrants in villages. This reflects an absence in control gradient preference after tsetse control.

Table 3.7: Determinants of the stock of first-generation migrants in 12 villages of Gokwe North District, Zimbabwe, between 1963 and 1995

Explanatory Variables	Parameter Estimates	
	Without Tsetse Control	With Tsetse Control
Constant (Ward 6: recent	3.3014**	-.3828
Ward 5 (less recent control)L5	-.4485**	.0432
Ward 4 (mid control)L4	-.7036**	-.2243
Ward 3(mid control)L3	-.4810**	.6978
Ward 2 (early control)L2	-.2977**	.6546
Ward 1 (early control) L1	-.5422**	-.0657
Cotton/Maize Price Ratio (R)	.0231	-.3311**
Time trend (T)	.0148	.0366**
Access to Markets	-.0359	.3183**
Access to Public Transport	.8600**	.5457**
Access to Schools	-.4593**	-.2479**
Access to Health Centers	-	-.1386

** $p < 0.05$ R2 = 0.68 F = 39.1

Source: Socio-Economic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Zimbabwe, 1996-97

Growth rates: The instantaneous growth rate of immigrant households was positive with or without tsetse control. With tsetse control, the effect of an additional year on the stock of migrants was to increase the stock by 3.7%. Without tsetse control, the effect of an additional year on the stock of migrants was to increase the stock by 1.5% per year.

While the effect of time was statistically significant with tsetse control, it was not statistically significant without tsetse control. Overall it can be concluded that, everything else equal, tsetse control was associated with an increase in the annual rate of immigration by about 150%.

Cotton / Maize Price Ratio: The results indicate no relationship between the price ratio and migration before tsetse control but a negative relationship occurred after tsetse control. Following the logic presented above, this implies that most of the migrant households who moved to the study sites after tsetse control were food insecure in their previous locations.

Amenities: Access to public transport was a significant immigrant attractant with and without tsetse control. Immigrants settled in villages that had public transport despite the presence of tsetse flies. Provision of roads and public transport increased the stock of immigrants by 80% without control and 55% with tsetse control. Access to crop markets was an important amenity at the time of immigration. With tsetse control, access to markets increased immigration by 32%, while it had no effect without tsetse control. Apparently, the ability to take advantage of markets depended on producing a crop surplus.

The relationship between migrant accumulation and access to schools was significantly negative. Migrants moved into villages with poor access to schools even after tsetse control. Apparently access to schools was not a significant attractant at the time of migration. The relationship between access to health services and migration after tsetse control was negative but insignificant. Again, it appears that immigrants may have failed to settle in villages with health centers but the health centers were not an essential service at the time of settlement.

3.4 Importance of Tsetse Control and other Amenities

The quantitative assessment of factors affecting immigration was augmented by a study of immigrants' perceptions of the importance of tsetse control and public amenities on their decision to move into their village in Gokwe North. In particular, first-generation immigrants were asked whether or not they thought that tsetse control or public amenities had important effects on their decision to migrate. The questionnaire indicates that the majority (88%) of immigrants who moved in prior to tsetse control felt that the degree of tsetse infestation did not affect their decision regarding where to settle within Gokwe North. The data summarized in Table 3.8 show a third of the immigrants were not even aware of the presence of tsetse when they settled in tsetse infested areas.

About two thirds of the migrants appeared to be aware of tsetse presence at the time they settled. Half of these migrants discounted tsetse presence because they had no livestock

when they moved in and perceived that the flies would not be detrimental to human health. The other half discounted the presence of tsetse because their only interest was to gain access to more land. Based on assessments from migrants who moved in before tsetse control, it appears that tsetse infestation most deterred migration of households that wanted to move with their cattle.

Table 3.8: Reasons Why Immigrants Perceived Tsetse Challenge as or not Important When They Chose a Settlement Site in Gokwe North Before, During and After Tsetse Control, Zimbabwe, 1996

Importance of tsetse/trypanosomosis	Before	During	After
I had many cattle which would have died	2	11	9
I wanted to avoid tsetse bites and sleeping sickness	0	2	12
I knew tsetse control was ongoing	1	8	0
Total number in sub-group	3	21	21
% Subgroup in valid sample	*12.0*	*46.7*	*33.9*
Insignificance of tsetse/trypanosomosis			
I only wanted land	8	6	11
I knew nothing about tsetse	8	9	9
There were settlements there and people survived	4	2	0
Tsetse flies had been cleared	0	1	18
I had no livestock	2	6	3
Total number in subgroup	22	24	41
% Subgroup in valid sample	*88.0*	*54.3*	*66.1*
Missing cases	1	0	5
Total sample	27	47	68

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Zimbabwe, 1996-97.

The questionnaire indicates that over half of the migrants who moved in during tsetse control considered the degree of tsetse challenge as important in their decision of where to settle. One of the reasons (53%) this group of migrants gave a premium to tsetse controlled areas was because they owned cattle which could have been lost due to trypanosomosis (Table 3.8). The other migrants wanted to keep cattle and chose areas that they knew were controlled or were about to be controlled. A few of these migrants wanted to avoid the nuisance of tsetse bites. Those migrants who moved in during tsetse control but discounted the importance of tsetse control did so because of ignorance of tsetse (36%), non-ownership of cattle (33%), and interest only in obtaining land (31%).

Table 3.9 shows respondents' assessments of the importance of public amenities to the inflow of migrants. When migrants selected potential sites for settlement, about two thirds of them felt they gave a premium to those villages that had good access to public amenities. The most important amenities, in terms of the number of times respondents referred to them, were schools, retail shops, roads and health centres.

The group of migrants who discounted the importance of the infrastructure did so for different reasons. Forty-five percent believed that new settlement would stimulate the development of public amenities. The remainder indicated that they were primarily interested in gaining access to more land and that everything else was of minor

importance. Villages that were abundant in land were sparsely settled and poorly serviced with amenities.

Table 3.9: Reasons why immigrants perceived infrastructure to be important or not important when they chose a settlement site in Gokwe North before, during and after tsetse control, Zimbabwe, 1996

Reason infrastructure was important	Before	During	After
Good roads required for public transport	3	5	13
Health centers needed for disease treatment	4	2	9
Infant schools within walking distance convenient	2	13	17
Short distances to grocery stores are convenient	3	6	15
No reason given	1	1	0
Total sample	13	27	54
Reason infrastructure not important			
There was no infrastructure to think of	2	1	3
The infrastructure is attracted by settlement	4	15	4
I only wanted land	7	4	4
No reason given	1	0	3
Total sample	14	20	14

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Zimbabwe, 1996-97.

3.5 Summary

Abandonment of old settlements was occurring due to overcrowding in Masvingo and Midlands provinces. Emigration from those areas was inspired by people's desires to access more farm resources in order to increase household food security and produce cash crops. The overriding desire behind emigration was getting access to more land.

Tsetse control had a large and significant impact on the rate of immigration; everything else equal, migration increased by 150% after tsetse control. It is not clear whether immigrants were reacting to tsetse control or other broad but concurrent national policies. Nonetheless, immigration started well before the areas were cleared of tsetse flies. Whether immigrants anticipated tsetse control when they moved into settlements with tsetse control is a moot point. Settlers who did not own cattle at the time of migration appear to have been less concerned about the presence of tsetse and trypanosomosis. Other settlers who moved in with cattle settled in areas with disease control in anticipation of vector control.

Besides tsetse control, primary roads were important public infrastructure. Good roads reduced the transportation and communication costs that were important in market transactions. Many of the primary and secondary roads in the sites started as tracks established by tsetse control gangs as they moved supplies around the area. Good roads and services also facilitated migration. Migrants stated their preference for villages with roads, schools, clinics and convenient stores nearby. However, such a desire was mostly unmet because it was secondary and only relevant after arable land had been secured. Failure to find villages with nearby schools and clinics was not critical to migration. Immigrants may have expected that the amenities would follow immigration after the areas became more populated.

CHAPTER 4: FARMING SYSTEMS CHANGE WITH TSETSE CONTROL AND IMMIGRATION

4.0 Introduction

The focus of this chapter is on (1) the effect of increased immigration and investment in tsetse control on the rate of adoption of cattle per village and (2) the impacts of introducing animal traction technology on farm productivity. In addressing the first objective, this chapter will seek to explain how tsetse eradication affects the rate of cattle adoption at the village level. One of the study's hypotheses is that cattle adoption was feasible with disease control but the impact of tsetse control was to enhance the returns to cattle adoption. To address the second objective, the study will provide answers to whether animal traction use and ownership contribute to difference in the stage of operation on the production function. The study hypothesizes that renters and owners operate within the same stage along the production function.

4.1 Adoption of Animal Traction Technology

Adoption can be considered a problem of reallocating resources in response to opportunities provided by the introduction of new techniques (Schultz 1975). The probability of a farmer adopting a particular technique can be influenced by several factors including farm size, quantity of family labor, proximity to market, human capital, capital availability, input and output prices, agricultural information, production uncertainty, nonfarm income earnings and risk (Rauniyar & Goode 1996). Wozniak (1986) examined

the extent to which differences in human capital and knowledge of the new technology explain differences in the speed with which individuals adopted new techniques. The evidence shows that education and information enhanced the ability to reduce costs of adoption. Cattle adoption in Gokwe North, is hypothesized to be endogenously driven by the process of in-migration. Immigrants into Gokwe North had training and experience in cattle breeding prior to in-migrating and were instrumental in spreading adoption among indigenous settlers. In Chiawa, Zambia, Brinn (1996) found that the introduction of cattle into a tsetse control zone was due to in-migration. Immigrants were experiencing a shortage of pastures in adjacent tsetse cleared areas. In Chiawa, Brinn found that 65% of the immigrants moved into the control zone with cattle and the remaining immigrants acquired cattle after settling-in. Cattle acquisition by indigenous settlers of Chiawa was well below the levels of immigrant settlers.

Immigration was one among several driving forces for adoption. The reduction in the risk of contracting trypanosomosis was an important element in cattle adoption in Gokwe North. Although tsetse flies presented an enormous challenge to cattle breeding and made it a risky venture, Reid (1994) found that tsetse fly control was not necessary for the introduction of cattle breeding in the Zambezi Valley. The study hypothesizes that the introduction of cattle in the Gokwe North was possible due to the availability of preventative and curative drugs. According to findings by Reid (1994) and Pender and Rosenburg (1995), the acceleration in livestock productivity growth in herd size and

increase in number of owners was strongly depended on tsetse control. Tsetse control reduced the risk and health management costs and boosted returns to adoption.

Animal traction is a relatively costly package or lumpy investment for most smallholder farmers. Non-farm income, therefore becomes a crucial liquidity source for investments in capital formation (Savadogo et al, 1998) substituting for formal or informal credit. This alternative source of income makes farmers more amenable to bearing the risk of farm investments including purchase of cattle. Savings from wage earnings, remittances and to a lessor extent gifts/grants positively affect the probabilities of adopting animal traction technology.

Farmers' ability to invest in farm capital is also contingent on making a significant production of a marketable surplus. Households who are less commercial oriented are expected to have liquidity problems limiting their ability to invest in capital formation. The relationship between commercial crop production and farm capital investments is synergistic. Farmers who rely on hand tillage are expected to market a small proportion of their output and unless these farmers have non-farm income, they struggle to invest in capital formation and fail to increase the proportion of their output they market as surplus. Savadogo et al (1998) studied the links from commercialization to animal traction investment and subsequently to technical and allocative efficiency. This study hypothesizes that during periods when cash crop prices are attractive relative to

subsistence crops, farmers take advantage of the opportunity to invest in capital formation. Relatively high cash crop prices and low food prices are important incentives for farm investment.

4.2 Estimating Rate of Livestock Adoption

To explore the effects of tsetse control and immigration on cattle adoption at the village level, a two-stage least square estimation was used. Immigration and cattle adoption occurred simultaneously within a village and it is therefore necessary to use an instrumental variable approach. This required developing a conditional cattle adoption function and an immigration function. The immigration function developed in the previous chapter is adopted to complete this task.

The cattle adoption variable is an aggregate annual measure of the number of settlers adopting cattle for the first time in a village. These data are used in order to capture the shape of the time dependent diffusion process. The pattern of adoption is modeled as a logistic-shaped exponential function. The theoretical framework of the determinants of immigration on cattle adoption is presented in the two equations below.

The conditional cattle adoption function is:

$$lnC_{it} = lnA_0 + A_1 lnX_{it} + A_2 lnM_{it} + rt + u_{it} \text{ (i = 1,...12 villages; t = 1,...33 years);} \quad (4.1)$$

And the immigration function is:

$$lnM_{it} = lnB_0 + B_1 lnX_{it} + B_2 lnF_{it} + rt + v_{it} \quad (4.2)$$

where C_{ij} is the stock of cattle adopters in a given year and village; X_{ij} is a vector of exogenous village and macroeconomic variables; M_{ij} is a vector of endogenous variables; and F_{ij} is a vector of instrumental variables used to predict C_{ij} and u_{ij} and v_{ij} are residual terms and r is a constant – the instantaneous rate of growth of cattle adopters in a village at any given time. The specific exogenous, endogenous and instrumental variables and their expected signs are found in Table 4.1.

Table 4.1 Description of Variables Included in Models

	Anticipated Sign	
	Stock of Immigrants	Stock of Cattle Adopters
Exogenous Variables (X_{ij})		
Location with recent tsetse control =1 otherwise = 0	?	?
Location with mid tsetse control =1 otherwise = 0	?	?
Location with early tsetse control =1 otherwise =0	?	?
Time trend (number)	+	+
Cotton to Maize Price Ratio	+	+
Period with tsetse Control = 1 otherwise =0	+	+
Endogenous variables (M_{ij})		
Stock of immigrants in village in a given year (number)		+
Instrumental variables (F_{ij})		
Access to public transport good =1 otherwise =0	+	IV
Access to schools good =1 otherwise = 0	+	IV

The selection of instrumental variables was driven by the hypothesis that these variables are strongly correlated with stock of immigrants and weekly associated with the stock of cattle adopters. The construction of roads was hypothesized to be critical in attracting immigrants who had to move in with their belongings. Villages with good access to schools were also expected to attract more immigrants than those villages without schools. The majority of the immigrant families were young and their children were attending school.

4.3 Animal Traction and Factor Productivity

Animal traction studies in Sub-Saharan Africa have failed to distinguish the impacts of ownership and use of animal traction. Ownership of draft animals and ploughs does not necessarily translate to use while use of animal traction services does not require ownership if a market for custom service exists. Previous animal traction studies focus on technical and allocative efficiency by examining impacts on cropped area, yields, cropping pattern and labor productivity. In Sub-Saharan Africa, evidence on the direction and magnitude of the impacts is not entirely consistent.

A study on animal traction conducted by Panin (1989) in Ghana reported that animal traction users held larger land holdings than hoe users. However, Panin could not establish causality and failed to substantiate whether larger land endowment was a product or cause of animal traction use. Savadogo's (1998) study suggested that large farm

holdings doubled the probability of adopting animal traction. A study in Upper Volta by Barrett et al (1982 & 1984) and another by Farnham (1996) in Togo, found animal traction users cropping larger areas per family than non uses. In Ethiopia, Gryseels et al (1984) found a related pattern between the number of oxen owned and the area planted per family. It is not clear whether the differences in cropped area are due to larger family sizes or larger numbers of active workers. For example, Farnham (1996) found that families of animal traction users grew faster than that of hoe users because the former married additional spouses but Farnham could not attribute this faster growth to use of oxen.

Neither is it easy to attribute use of animal traction to size of family but Savadogo's study (1998) did confirm results from other studies that families with four or less adult equivalence found it difficult to use animal traction. Barrett (1984) found insignificant differences in cropped area per capita between users and non-users. He argued that differences are better reflected by area cropped per active worker than per capita. As Barrett (1984) expected, Panin (1989) found the cropped area per active worker higher for animal traction users than hoe users. Evidence of how animal traction use could cause the area cropped to increase is found in Ethiopia where a study by Astatke and Mohammed Saleem (1996) confirmed that use of animal traction technology enabled improved surface drainage of vertisols and allowed farmers to utilize such soils. It is also clear that in agro-ecological zones with a relatively short rainy season, timing of land

preparation and planting operations are critical for overall production success. Within that short planting period, plough users and ox owners in particular, might be able to plant more hectares/day than hoe users.

The impact of animal traction ownership on crop yields is identified as positive but the significance of this impact is doubtful. Animal traction owners obtain higher yields than non-owners and evidence from Zimbabwe by Shumba (1994) confirms this. Animal traction owners had access to manure which improved soils nutrient status. However, Savadogo (1998) and Sanders et al (1996) found the effects of manure use insignificant because of low application levels. While this effect can be observed for owners, the effect on land productivity of using animal traction is mixed or insignificant at best. A case study on productivity determinants in Burkina Faso by Reardon et al (1996) reported strong impacts on land productivity. Panin (1989) and Ramisch (1996) reported increases in land productivity due to use of animal traction on average but particularly for major crops. In contrast, Barrett (1984) and Savadogo (1998) only found modest increases in land productivity. The causality between animal traction use and crop yields is difficult to identify and quantify without controlling for numerous other factors that affect yields, including soil nutrient status, crop variety, planting date and others.

Evidence on the impact of animal traction use on crop diversification is relatively consistent. Plough users commercialize to a higher degree than hoe users. Gryseels

(1984), found animal traction use associated strongly with cropping patterns. Barrett (1984) and Panin (1989) found very slight shifts from staple food to cash crops. Dionne (1989) and Farnham (1996) found that animal traction users grew more food and cash crops. The debate over the shift towards commercialization cannot be adequately addressed by looking at food versus cash crops. Instead, the proportion of output that is marketed as surplus is a more comprehensive measure and provides a better indicator of cropping system changes. An important finding from Dionne (1989) and supported by Farnham (1996) is that animal traction users were also self-sufficient in grain. Hoe users were potentially vulnerable from food and income insecurity.

Studies on the impacts of animal traction use on labor productivity show overall positive effects. By examining the average value product, Savadogo (1998) found the effect of animal traction use on labor productivity to be higher than the effects on land productivity. Panin (1989), Farnham (1996) and Ramisch (1996) found that use of animal traction reduced labor requirements per family during land preparation and planting but disagree on the impacts on weeding. Ramisch (1996) contends that the requirements per family for weeding will be reduced but Panin (1989) and Farnham (1996) suggest that labor required for weeding increases. The qualifier could be that adoption of secondary tillage reduces labor required for weeding per hectare but requirements per family might increase when the cropped area increases as well. However, use of animal traction causes a labor bottleneck for the family during harvesting and the evidence for this is consistent. Overall,

the labor demand per hectare cropped is significantly reduced (Barrett 1984) suggesting that the impacts on labor productivity are strong as shown by Reardon (1996).

Comparisons of "with and without" animal traction have dominated the literature while comparisons of "before and after" are very few (Petheram *et al* 1989). The explanation advanced by Petheram (1989) is that "with and without" scenario comparison tends to overestimate the impacts of animal traction unlike "before and after" studies. He alleges that the former approach confounds other factors like family size with the impact of animal traction (Petheram et al, 1989). The "with and without" comparison is the preferred method because it holds other factors constant. Historical accounts of before and after, however, assume that these other factors e.g., family and farm size are constant, but they also change. This methodological challenge requires a longitudinal approach in order to capture changes of other factors over time and separate their effects from the impacts of animal traction use.

While one can perform comparisons of plough and non-plough users, establishing causality due to animal traction use is difficult. The performance difference between plough and non-plough users is a function of other variables apart from animal traction. Barrett (1984) found that plough users had higher education, were innovative and more successful than hoe farmers. To determine the impact of animal traction on crop production requires the elimination of the impacts due to other variables first.

Production function analysis has been the common approach for estimating the impact of animal traction apart from other factors. The magnitude and direction of the coefficients in the estimated production function model indicate the influence of each production factor. The values of the estimated parameters are the production elasticities of the respective production factor. For each production factor, the elasticity indicates the percentage change in total output that would occur by a unit percentage change in that particular factor holding all other factor levels, constant. The factor with the highest elasticity value is the factor that will increase output by the highest margin.

4.4 Estimating Impacts of Animal Traction

To analyze the responsiveness of factor productivity to investment in capital formation at the household level, an econometric model is developed to model the relationship between gross value of total crop output with investment in animal traction, farm size, family size and education of decision makers. Given that all the explanatory variables are exogenous to the dependent variable, an OLS estimation was used to explore the effects of these factors on aggregate crop production. Owing to lack of crop specific input data, an aggregate total farm production function approach was adopted.

The production function was of the Cobb-Douglas form:

$$Q_i = AK^a_i L^b_i N^c_i M^d_i \quad (i=1,\ldots,453 \text{ households}) \qquad (4.3)$$

Where Q_i represents the aggregate value (Z$) of crop output, K_i represents the value of investment in animal draft and equipment (Z$), L_i is the household size; D_i is the farm size (ha); M_i is the level of education of husband and wife (years in school) and A represents the state of technology. This Cobb-Douglas function form is linear in logarithms (4.4). That is:

$$LnQ_i = lnA + alnK_i + blnL_i + clnN_i + dlnM_i + u_i \qquad (4.4)$$

4.5 Adoption Trends and Characteristics of Farmer Adopters

Of the 452 households considered in this study, 61% had adopted cattle during their period of residence in the study sites. Cattle adoption represents a lumpy type of investment. As expected, a sizable proportion of the settlers had not generated adequate resources to make this investment. The absence of a well-functioning livestock credit market means cattle adoption depends on one's personal savings.

Table 4.2 indicates the number of households and the period when they adopted cattle for the first time in each village. About 25% of the adoption occurred before tsetse flies were controlled. It is not well known whether the cattle were resistant to the disease. The conventional wisdom is that such adopters had to rely on drugs to prevent the risk of contracting disease and to cure trypanosomosis. Adoption of cattle during this period was discouraged because it stretched out the resources of the department of veterinary services responsible for administering the drugs free of charge. Another 41% of the sample

households adopted cattle during the period when tsetse flies were being actively eradicated. Adoption of cattle during tsetse control operations was restricted to avoid prejudicing the success of tsetse control campaigns.

Table 4.2 The Number of Additional Cattle Adopters in Villages 1963 – 1995, Gokwe North, Zimbabwe, 1996[a]

Village by Name	Period of Adoption							
	<1966	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95	Total
Tofe	3	4	3	2	5	6	5	28
Goredema	6	4	4	2	10	2	1	29
Nevana	0	2	7	6	4	1	0	20
Nyahomba	3	1	4	2	3	2	3	18
Kakwari I	0	0	1	1	13	7	8	30
Kakwari II	3	0	1	1	6	8	10	29
Nechinyika	0	0	0	2	2	12	7	23
Mayava	3	0	3	3	4	8	2	23
Chirudzi	3	0	2	7	4	7	4	27
Kwaedza	2	4	2	1	5	6	6	26
Ntamo	0	0	0	0	0	0	6	6
Chirisa	5	2	2	3	6	2	10	30
TOTAL	28	17	29	30	62	61	62	289
Total # of Immigrants	*11*	*9*	*6*	*11*	*45*	*30*	*29*	*141*

[a]the shaded cells indicate periods of active tsetse control in each village
Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Zimbabwe, 1996-97

Many migrants brought livestock capital with them to the Valley, Table 4.3. This is particularly so for the migrants who moved into areas that had tsetse control relatively recently. Among the migrants into the late clearance areas, 45% brought some cattle, 40% brought some goats, 18% brought some donkeys, and 7% brought some sheep.

At the time of the survey, 23% more of the migrant households held cattle, 8% more held donkeys, 3% more held goats and 6% more held sheep. Indeed, migrant households were more likely to hold cattle at the time they migrated as indigenous households were overall, Table 4.4.

Table 4.3: Migrants' livestock holdings at the time that they migrate into Gokwe North District, Zimbabwe, 1995/96

	% households holding species at time of immigration		
	Early clearance	Mid clearance	Late clearance
Cattle	21	26	45
Donkeys	10	16	18
Goats	25	16	40
Sheep	6	8	7

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Zimbabwe, 1996-97

Table 4.4: Percentages of pioneer and newcomer households owning livestock at time of Survey in Gokwe North District, Zimbabwe, 1995/96

	Pioneer Settlers	Newcomers
Cattle	38	61
Donkeys	37	45
Goats	76	79
Sheep	18	24

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Zimbabwe, 1996-97

Sources of finance to acquire livestock suggest the existence of a possible synergistic relationship between livestock and other economic activities, Table 4.5. Production of cotton was a major activity generating cash to purchase livestock. Other crop sales included maize. Besides crop surplus, off-farm employment generated savings used in livestock acquisition.

Table 4.5 Major sources of finance for acquiring livestock, Gokwe North District, Zimbabwe, 1995/96

	% of households with species			
	Cattle	Donkeys	Goats	Sheep
Cotton sales	53	49	38	38
Cotton & maize sales	14	16	13	12
Other crop sales	5	10	12	12
Gifts	7	13	12	19
Salary savings	18	9	18	17
Non-agric. Sales	3	3	6	2

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Zimbabwe, 1996-97

4.6 Characteristics of Households Using Different Tillage Systems

Table 4.6 presents descriptive information about production practices and resource characteristics of smallholder producers using different tillage systems. There are large differences between ox owners and ox renters and between ox renters and those who cultivate by hand. These trends are especially strong for farm size, grain output per capita,

total income per capita, degree of self-sufficiency, marketing of grain, and degree of commercialization.

These trends do not hold for grain and total crop yields. On the contrary, yields are higher for hand cultivators than for ox owners. In sum, however, multiplying yields by area, ox owners generated much higher revenues per capita than either ox renters or hand cultivators. Furthermore, ox renters generated twice as much revenue per capita than hand cultivators.

The commercialization index measured by the proportion of output that is marketed shows that ox owners were most commercialized marketing about 78% of their output as compared to 51% for hand cultivators. The proportion of cropped land placed under cotton was 175% higher for ox owners than hand cultivators. The proportion of ox owners who were self-sufficient in grain was 62% as compared to 49% for hand cultivators. Animal traction facilitated a higher degree of both commercialization and self-sufficient production of food crops than hand cultivation. There was no difference in the grain commercialization index between these smallholder groups.

Ox owners invested most in farm equipment than the other two groups. Farm equipment made crop production and carting inputs and products less laborious. Farmers without access to transport resorted to head-loading.

Table 4.6: Characteristics of Farming Systems by Type of Tillage, Gokwe North District, Zimbabwe, 1995/96

Characteristics	Oxen Owners	Oxen Renters	Hand Tillage	Total
Grain Yield (kg/ha)	1218	1070	997	1136
Grain Output (kg/capita)	286	368	468	386
Gross Grain Z$/ha	1523	1337	1246	1348
Gross Grain Z$/capita	357	461	585	483
Total Crop Z$/ha	2440	2272	2352	2341
Total Crop Z$/capita	962	1570	2237	1676
% Cotton to total output	38.77	57.84	66.96	56.89
% Grain surplus to total output	11.93	11.13	10.76	11.17
% Sales to total output	50.70	68.97	77.72	68.06
% Area under Cotton	28.0	41.6	46.0	40.2
% Cotton Growers	57.5	86.9	92.8	82.6
% Food self-sufficient	48.9	58.2	61.8	57.3
% Selling grain	14.9	27.7	34.9	27.3
Land Size (ha)	4.24	5.51	7.67	6.1
Fallow Area (ha)	1.13	.81	.73	.85
Family Size (No.)	6.3	6.2	6.9	6.5
Animal Traction Investment (Z$)	1720	3718	12090	6241
Years Farming (yrs)	13.3	12.1	13.5	12.8
Household head's age (yrs)	45.7	43	47.6	45.3
Total years in school for husband and wife	7.23	10.71	11.22	10.1
Distance to Market (km)	26.9	25.9	22.6	25.0
Late tsetse control (%)	41	36	24	33
Mid tsetse control (%)	1	31	58	34
Early tsetse control (%)	58	33	18	33

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Gokwe North District, Zimbabwe, 1996/97.

4.7 Growth in Cattle Adoption

Table 4.7 shows results of the OLS estimation of immigration flows and an instrumental variable model of cattle adoption. The results of the immigration model, equation 3.4 in Chapter 3 have been discussed already. This section will show how the number of new cattle adopters in each year for each village changes when immigration increases while holding other factors constant.

Constant: The estimate of the constant predicts that there were 1.5 cattle adopters per village prior to 1963. Although this result was least expected, it was insignificant. The degree of tsetse challenge made cattle adoption very risky. According to this model, there is no evidence to suggest that ownership of cattle in Gokwe North can be entirely attributed to in-migration and tsetse control.

Tsetse control gradient: Adoption of cattle in those villages cleared of tsetse flies earlier was higher than the levels of adoption in recently cleared areas. The differences in the levels of cattle adoption between villages along the tsetse control gradient were significant ($p=.01$). Although all villages are free from tsetse, the adoption levels differ. Besides the gradient of time of tsetse control, other factors may play a role in determining the levels of adoption. Recently cleared areas have newer settlements and settlers may still be adapting to their new situations and not ready to make investments.

Period With or Without Tsetse Control: The result shows an unexpected 40.15% more adoption of cattle without tsetse control than with control. This result was significant at p=.044. The adoption of cattle by settlers appeared to be a step ahead of active tsetse control efforts. Such levels of adoption prior to tsetse control could have been induced by in-migration into these villages. Immigrants illegally drove cattle into these villages prior to tsetse control. Settlers in tsetse infested villages could adopt cattle as long as they used preventative and curative drugs against trypanosomosis.

Growth rates: Although insignificant, the uniform rate of growth of the cattle adoption function r, was -2.23% per year between 1965-96. If this rate r prevailing in 1996 is allowed to continue undisturbed, then C_{it} will have grown by the amount rC_{it} by the end of 1997. The stock of cattle adopters in each village was increasing at a decreasing rate each year but the absolute amount of increment of C_{it} increases as time goes on. This negative growth rate is not a surprise. Innovative settlers with the resources to invest have already done so. Potential adopters may be laggards struggling to break the poverty cycle. Lack of formal livestock credit markets may explain why there is a negative growth rate in cattle adoption over time.

Table 4.7: Results of Econometric Models of the Flow of Immigrants and Cattle Adopters, Gokwe North District, Zimbabwe, 1965 -96

	Immigrants in Each Village Each Year (OLS)		Cattle Adopters Per Village Each Year (IV)	
Endogenous Variables	Coeficient	T-stat	Coefficient	T-stat
Immigrants/village/year			1.9024	6.307**
Exogenous Variables				
Cotton/Maize Price Ratio (1 year lag)	-.288	-2.756**	.4530	2.060**
Tsetse Clearance	.379	3.651**	-.5134	-2.020**
Time trend	.0457	8.508**	-.0226	1.347
Early Cleared Ward 2	.455	4.482**	-1.1496	-4.938**
Mid Cleared Ward 3	.0208	.176	-1.0550	-4.786**
Mid Cleared Ward 4	.183	1.531	-1.2674	-5.481**
Late Cleared Ward 5	.321	3.030**	-2.1661	-8.843**
Late Cleared Ward 6	-.354	-2.938**	-.2730	-1.270
Constant	.652	3.766**	.4096	1.147
Instrumental Variables				
Availability of schools	-.393	-5.728**		
Availability of public transport	.392	4.200**		
S.E.	.5540		1.0806	
N	383		383	
Adjusted R-square	.607		.4577	

** denotes statistical significance (one-tailed test) at the 5% level

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Gokwe North District, Zimbabwe, 1996/97.

Elasticity of Cotton to Maize Price Ratio: The adoption of cattle increased significantly as the ratio to real cotton to maize price increased. The results reveal a less than unitary measure of responsiveness, that is, a 1% increase in the ratio was associated with a .453%

increase in the level of cattle adoption. This result was as predicted. A shift in the balance of cropping incentives in favor of cash crops made livestock adoption more likely. Whenever the macroeconomic environment makes food cheap relative to farm incomes, farmers are presented with an incentive to make farm investments.

Elasticity of Immigrant Stocks: The results in Table 4.6 highlight the complementary relationship that exists between immigration and cattle adoption. The immigration elasticity of cattle adoption was elastic achieving 1.9% increase in cattle adoption for each 1% increase in immigration. Immigrants were instrumental in the spread of cattle adoption in the study sites.

4.8 Production function analysis

The estimated model is presented in equation (4.5) and other statistics are in Table 4.7.

$$Q_i = 709.1K^{.075}L^{.214}N^{.527}M^{.101} \quad (4.5)$$

The model explains 32.4% of the variation in the aggregate value of crop output between the sampled households. The overall model is statistically significant. The effect of all the variables on crop output was significantly different from zero at the 1% level of confidence.

Table 4.8: Results of Cobb-Douglas Model of Value of Aggregate Crop Output, Gokwe North District, Zimbabwe, 1995/96

	Dep. Var. is Total Gross Crop Value (Z$)		
	Coefficient	T-statistic	Mean
Exogenous Variables			
Farm Size (ha)	.527	7.856**	6.04
Family Size (adult equivalence)	.214	2.767**	6.46
Value of Animal Traction (Z$)	.075	5.364**	6241
Level of Education (years in school)	.101	2.386**	10.1
Constant	6.564	35.095**	
S.E	.853		
N	425		
Adjusted R-square	.324		

** denotes statistical significance (one-tailed test) at the 5% level
Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Gokwe North District, Zimbabwe, 1996/97.

4.8.1 Elasticities:

The elasticity of total crop value with respect to farm size was statistically significant from zero. An increase in farm size by one percent increases output by .527%. An increase in farm size by one percent from 6.04 to 6.1 hectares costs $14.82 in the rental market and led to an increases in output of $41.66, all other input levels constant.

The elasticity of output with respect to labor was statistically significant. An increase in labor by one percent leads to an increase in output of .214%. This responsiveness means

that an increase in crop value of $16.92 is achieved with an increase of $5.00 in labor costs, *ceteris paribus*.

The elasticity of output with respect to investment in animal traction and equipment was statistically significant from zero. For every increase in capital of 1%, output increased by .075%. In value terms, an increased investment in animal traction of $62.41 was associated with an increase in output of $5.93. On face value, this magnitude of responsiveness appears unattractive. However, investment in animal traction has multiple purposes and lasts for several production seasons. A careful estimation is required to assess the profitability of adopting animal traction at the household level. The results also show that the quality of management, measured by the education level of both decision makers, significantly affect crop output. Crops such as cotton demand a high level of discipline in input management. Decisions such as determining economic injury due to pest infestation are very technical.

4.8.2 Returns to Scale:

The returns to scale exhibited by the estimated production function shows that there is less than proportionate increase in output when all inputs are increased. This result indicates that there are substantial problems with increasing farm size above the average of 6.04 hectares. There are logistical problems in managing a larger pool of workers (especially if they are hired), additional farm land (especially if the plots are in different locations) and

additional farm animals (especially with limited pasture). Hence careful calculations are required in deciding to trade-off the advantages and disadvantages of large smallholder farms.

4.9 Ownership versus Hiring Animal Traction

The returns to factor productivity between ox owners and ox renters are not necessarily uniform. What is also certain is that neither the strategy for intensifying production nor approaches to increasing technical efficiency at the farm level are uniform across farmers with different capacities. The following results reveal important insights that can help increase understanding of various alternatives for increasing farm productivity for farmers with diverse resource capacities.

The results from the production function analysis are used to estimate factor productivity, technical efficiency, rate of technical substitution and cross-productivity effects. Table 4.8 reports estimates of these indicators for three types of farm households: farmers who use and own oxen; farmers who rent-in oxen; and farmers who use hand tillage.

4.9.1 Marginal Productivity

Differentiating equation (4.5) with respect to each factor generates estimates of the value of marginal products. The value of marginal product of a production factor is the value of

farm output that results from a unit increase in the production factor, all other factors constant.

The results show that ox owner's labor is most productive at the margin Table 4.8. This group of farmers can get the highest returns to additional investment in labor. Ox owner's labor is 19% more productive than ox renters, but 57% more productive than hand tillage farmers. Farmers using hand tillage are most productive in their use of land and capital at the margin. This is the case because these farmers have limited capital investment. Hoe tillers can obtain highest returns by investing in additional farm capital than the return ox owners and ox renters would get by additional investment in animal traction. The productivity of farm capital investment of ox renters is more than double that of ox owners suggesting that ox renters could get higher returns for marginal investment in farm capital than ox owners. Ownership of oxen appeared to generate important differences in partial factor productivity.

4.9.2 Marginal Rate of Technical Substitution

Table 4.8 also shows estimates of the rate of technical substitution between labor, capital and land. The marginal rate of technical substitution shows the rate at which labor can be substituted for capital while holding output constant. At the average level of input combinations, labor substitutes for nine times the amount of capital of extensive users than hoe-tillers. This result implies that extensive plough users are nine times more capital

extensive than hoe users. Among ox renters, the value of capital that a unit of labor can substitute for is less than a third more than what labor substitutes for among hand tillage farmers. Overall, ox owners had a higher marginal rate of substitution for the three inputs implying that they were also land and labor extensive than either ox renters or hoe-tillers. Unlike access, ownership of oxen appeared to generate differences in factor extensification.

4.9.3 Cross-Productivity Effects

Table 5.8 also reports estimates of the cross-productivity effects between labor, capital and land for the three groups of farmers. Cross-productivity effects are derived from the cross-partial derivative and are a measure of how an increase in one factor effects the marginal productivity of another factor. If hand tillers had more capital, they would increase the marginal productivity of labor and land by a magnitude four times higher than that achieved by ox owners. By increasing capital at the margin, ox renters would increase marginal labor productivity by a factor two times greater than the increase achieved by ox owners. Additional amount of land increased marginal labor productivity to ox owners by the greatest margin but the difference in the increase in marginal labor productivity between ox owners and ox renters is very small. Additional levels of labor increased marginal productivity of capital to hand tillers by the greatest margin. The increase in marginal productivity of capital by increasing labor at the margin was twice greater for ox renters than owners.

Table 4.9: Value of Marginal Products, rate of Technical Substitution and Cross Productivity Effects for Land, Labor and Capital by Traction Use, Gokwe North District, Zimbabwe, 1995/96

	Extensive plough users	Casual plough users	Hoe Tillage	All farms
Average Product Value				
Land	1375.2	1318.2	1087	1308.7
Labor	.875	1.99	2.67	1.27
Capital	1533.5	1197	728.4	1224.1
Marginal Productivity				
Land	557.10	574.43	599.26	578.67
Labor	252.39	211.31	161.73	218.06
Capital	.05	.12	.21	.08
Technical Efficiency				
Land	.405	.436	.551	.442
Labor	.058	.06	.079	.063
Capital	.165	.176	.221	.178
Rate of Technical Substitution				
$RTS_{\text{Labor for Capital}}$	5047.8	1056.55	770.14	2725.75
$RTS_{\text{Labor for Land}}$	.453	.368	.270	.377
$RTS_{\text{Land for Capital}}$	11142	4789	2853	7233
Cross-Productivity Effects				
$MVP_{\text{Labor WRT Capital}}$	.00318	.0079	.01232	.00506
$MVP_{\text{Labor WRT Land}}$	50.73	49.24	43019	49.06
$MVP_{\text{Capital WRT Labor}}$	.00235	.00612	.0105	.00392
$MVP_{\text{Land WRT Capital}}$	.00701	.0215	.0457	.0134
$MVP_{\text{Capital WRT Land}}$	.01005	.02796	.05607	.018
$MVP_{\text{Land WRT Labor}}$	26.184	29.311	29.963	28.355

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Gokwe North District, Zimbabwe, 1996/97.

Increasing labor units at the margin generated almost equal impacts on marginal productivity of capital across farm types. The results also indicate that hand tillers increase their marginal productivity to capital the most by increasing land at the margin.

The marginal productivity of capital for ox renters for marginal increases in land is also greater than that of ox owners. However, hand tillage farmers and ox-renters cannot increase their land given constraints to their production process. It is clear, that to increase the marginal productivity of land and labor, intensifying capital investment was the best option for both hand tillers and ox renters. As for ox owners, their advantage was in increasing labor productivity by employing additional land in the production process. Unlike access to animal traction services, ox ownership made a difference in the strategy for increasing factor productivity.

4.8.4 Technical Efficiency

By synthesizing marginal and average products into a single measure (Savadogo 1998), we obtain an indicator of returns to fixed factors. The ratio of marginal to average products identifies the stage on the production function the farmer operates. The ratios reported in Table are between 0 and 1 suggesting that all the farm types are in stage 2 of the production process which is necessary for technical efficiency but not sufficient for economic efficiency. The ratios for hand tillage farms are the largest.

The results suggest that the production process of hand tillage farmers is pushing toward the limit of productivity relative to the animal traction farms which means that intensification investment is needed to maintain factor productivity. This evidence also suggests that hand tillage farms are relatively land and labor abundant. The differences in

ratios for all factors (capital, land and labor) between ox owners and ox renters were very small. These results suggest that ownership of oxen did not make much difference in technical efficiency. What matters most is access to animal traction services.

CHAPTER 5: DETERMINANTS OF WEALTH ACCUMULATION AND SOCIOECONOMIC MOBILITY

5.0 Introduction

Throughout the 20th Century, the Zambezi River Valley has had an economy characterized by settlement of new land by immigrants each year, (Govereh 1998). A major preoccupation of researchers has been studying the pace of wealth accumulation and the extent to which the settlement frontier presents equal opportunity to all immigrants. One common hypothesis is that a frontier such, as the Zambezi Valley, provides a *safety valve* to immigrant households. The safety valve thesis assumes the frontier has a leveling influence that promotes equality in both origin and destination areas (Turner 1920). The paper hypothesizes that destination areas provide the basis for upward mobility even for those immigrant households who are poor at the time of arrival.

5.1 Settlement frontiers as safety nets

The majority of studies (Soltow 1971; Kearl et al 1980 and Gregson 1996) examined wealth distribution of cross-sectional samples at specific periods of time. A few (Steckel 1990) took the extra step to analyze mobility or change in wealth holding longitudinally. This study uses the former approach to analyze wealth distribution of livestock, farm equipment and land improvements in 1996 and the latter approach to study accumulation of livestock and farm equipment wealth between 1987 and 1996.

Empirical evidence (Soltow 1971; Kearl *et al* 1980 and Gregson 1996) acknowledge that success of immigrant families in frontier settlements is not uniform. There is no widely accepted economic theory to explain the determinants of wealth holding or its distribution. The conventional approach is the rent analysis (Ricardo 1817). Ricardo's analysis of wealth distribution under conditions of population growth suggests a less equal distribution to occur because of the rise in rent for those production factors with inelastic supply, such as, land. More equality in wealth holding would be expected in the initial periods of immigration rather than later when the economy is mature. If follows that new settlements would be expected to have a more equal distribution of wealth than settlements established earlier. The standard model of wealth accumulation allows income Y to vary with age of household head (Gregson 1996). Assuming constant consumption C, at age a, the individual household's wealth is:

$$W_a = Integral\ (Y_t - C)e^{r(a-t)}dt \qquad (5.1)$$

where the constant r, is the interest rate at time t. The instantaneous growth rate of wealth at age a and time t is the first derivative of wealth W with respect to age.

Other variables that have been associated with variation in household wealth are household characteristics including time of immigration, place of birth, age, income, literacy, household size and occupation. The socioeconomic advancement of immigrant settlers goes through several stages (McMillan *et al* 1995) largely driven by the length of residential tenure. Soon after arrival, a settler goes through an adaptation or settling-in

stage. Settlers adapt for three to five years and during that period, they are preoccupied with establishing food security. Settlers with more than five years of tenure are considered as open to undergo a transition of economic and social development (McMillan et al 1993). The relative wealth for any settler would be a function of where they are on the settlement cycle.

What is given less attention in the literature is the variation in socioeconomic status of settlers at the time of settlement (Sewastynowicz 1986). The amount of capital held at the time of settlement determines how rapidly the household advances on the socioeconomic ladder. The prevalence of adverse physical conditions such as vector-borne diseases negatively affects the pace of socioeconomic mobility. This issue has been partially addressed through studies on settlements in the river basins of West Africa infested with onchocerciasis or river-blindness (McMillan 1995). In the Zambezi Valley, tsetse flies and trypanosomosis make it extremely difficult to raise livestock. Immigrant settlers who moved in well ahead of vector and disease control efforts would not be expected to be on a significantly different socioeconomic standing with settlers who arrived after the vector had been eradicated. Thus, the presence of tsetse flies and trypanosomosis wipes off the early arrival premium.

The following sections discuss the distribution and determinants of wealth among immigrants. A sub-sample of only those immigrants who settled before 1987 is used later to estimate the rapidity of wealth accumulation between 1987 and 1996.

5.2 Distribution of Wealth

Of the three sources of wealth studied, livestock assets provided the largest contribution of about 42%, followed by land improvements and then equipment assets Table 5.1.

Table 5.1 Distribution of Per Capita Wealth by Wealth Source Among Settlers in Gokwe North District, Zimbabwe, 1996.

	Source of Per Capita Wealth			
	Land Improvements	Livestock Assets	Equipment Assets	Total
Average ($/capita)	1675	2084	929	4684
Percentage with $0 (%)	0	18.7	21.8	0
% Wealth Held by				
Bottom 25%	10.73	.073	.31	6.24
Bottom 50%	27.95	4.32	7.01	17.81
Top 25%	46.94	79.48	74.29	61.66
Top 5%	17.58	41.84	32.38	28.73
Top 1%	7.56	20.04	15.37	12.39
Gini Coefficient	.32337	.72456	.64627	.62055

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Gokwe North, Zimbabwe, 1996-97.

Despite the largest contribution of livestock investments to total wealth, about 18.7% of the sampled farmers had neither small nor large ruminants. Every household in the sample

had made some form of investment in land improvements. Construction of residential buildings is a necessity and a priority especially for recent immigrants. About 22% of the sampled households had not made any investment in farm equipment. Households without animal traction were of course not expected to make investments in animal drawn equipment. The issue of what investment sequence farmers follow is debatable but simple logic suggests that farmers without animal traction do not own much equipment.

Overall the distribution of wealth is leaning towards inequality with a gini coefficient of .6206. The main source of this skewed distribution is in terms of livestock and equipment investments. With a gini coefficient of .7246, livestock investments represent the most unequally distributed asset among the three sources studied. The top 25% of the farmers in terms of livestock investments, owned about 80% of the total livestock assets and the top 1% owned about a fifth of all the livestock wealth. Similarly, investments in farm equipment were also concentrated. The top 25% farm equipment investors owned 75% of the total assets.

In contrast, land improvements are more equally distributed with a gini coefficient of .3234. This distribution suggests that such investments are essential as it includes investments in residential buildings. The nature of the distribution also suggests that these investments are a top priority particularly for recent settlers.

5.3 Association of Wealth Accumulation with Demographic Characteristics

The study established the patterns of association between independent sources of wealth and demographic characteristics of the household. The results are presented in Table 5.2.

Age of Household Head: Evidence in this study supports the life-cycle hypothesis that suggests an inverted U-shaped curve when wealth is plotted against age. Wealth accumulation by settlers in Gokwe North increased with age and approached a peak between 41-50 years of age and then wealth holding declines during the period of retirement. This pattern is particularly evident in the case of livestock and equipment investment. Notably, the 41-50 age group was significantly ($p=.05$) more resourceful than younger families and those with household heads above 60 years old.

Residential Tenure: When per capita wealth is plotted against years of residence, a pattern similar to the inverted U shape is shown. This is a departure from conventional wisdom suggesting that wealth is directly related with years of tenure. The view suggested in the literature is that residential tenure is associated with knowledge of local circumstances, information and social capital important in reducing transaction costs and prosperity. While this may be the correct pathway by which tenure affects wealth accumulation, the association revealed in this study was not sustained.

Table 5.2: Demographic Characteristics of Settler Households in Gokwe North District, Zimbabwe, 1996.

		Livestock		Equipment		Total Wealth	
	% N	% Sum	Mean ($)	% Sum	Mean $	% Sum	Mean ($)
AGE (years)							
< 31	18.5	10.4	1173	14.4	721	14.6	36833
31-40	25.2	19.7	1628	21.0	773	21.7	4038
41-50	23.9	37.3	3242	30.4	1180	32.5	6373
51-60	14.9	17.5	2456	17.2	1074	16.0	5024
> 60	17.5	15.0	1791	17.0	905	17.5	4074
Total/Average	**100**	**100**	**2082**	**100**	**929**	**100**	**4684**
TENURE (Years)							
< 5	24.4	13.7	1171	18.1	689	18.0	3553
5-10	19.4	18.2	1952	17	813	17.6	4256
11-15	21.0	37.2	3708	32.4	1438	32.6	7304
16-20	9.1	7.2	1661	8.8	900	7.6	3944
> 20	26.1	23.7	1888	23.8	848	23.6	4238
LOCATION							
Early	32.3	15.3	991	25.5	734	22.4	3624
Mid	34.0	61.8	3800	53.0	1451	53.7	7418
Recently	33.8	22.9	1421	21.5	596	23.9	3328
TIMING							
Before Control	28.0	26.5	1974	26.5	880	25.7	4301
During Control	23.5	42.9	3799	33.9	1339	35.7	7116
After Control	48.5	30.6	1312	39.6	758	38.6	3726
SETTLER STATUS							
Indigenous	42.5	19.2	941	27.4	598	26.6	2930
2nd G migrants	33.4	31.4	1958	36.3	1009	34.3	4810
1st G migrants	24.1	49.3	4259	36.3	1399	39.1	7594
GENDER							
Female	20.5	25.5	2887	20.8	949	23.4	5752
Male	79.5	74.5	1950	79.2	925	76.6	4510
FAMILY TYPE							
Polygamous	23.5	13.6	1203	17.2	681	14.7	2932
Monogamous	76.5	86.4	2352	82.8	1005	85.3	5222
NON-FARM							
Yes	47.3	59.3	2590	49.5	966	53.9	5299
No	52.7	40.7	1619	50.5	895	46.1	4124

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Gokwe North, Zimbabwe, 1996-97.

The association of tenure with wealth accumulation may be undermined by age. The group of settlers who had been settled 11-15 years held significantly the greatest per capita wealth. The difference in per capita wealth between recent settlers and early settlers was not significant. The expected impact of residential tenure on per capita wealth was not significant.

Tsetse Control Gradient: Locations that were along the mid-gradient of tsetse control had significantly the greatest per capita wealth holding. Recently cleared areas were still developing while early cleared areas might be experiencing pressure on resource access because of high settlement densities. There were no significant differences between early cleared areas and recently cleared areas. The tsetse control gradient is, therefore, not a good predictor of wealth holding.

Timing of Movement: Settlers who moved in during tsetse control had significantly accumulated the greatest per capita wealth. The differences in per capita wealth holding between settlers who moved in before and those who moved in after tsetse control were not significantly. Moving in before tsetse control meant that one could not invest in livestock while moving in after tsetse control limited the settlers to less suitable residential sites. Settlers who moved in during tsetse control minimized the risks of livestock investment losses but they also had the opportunity to select some of the best locations for siting residential as well as arable plots.

Settler Status: The settlers in Gokwe North could be divided into three distinct groups of: indigenous settlers; 2nd generation of newcomers; and 1st generation of newcomers. The 1st generation of newcomers was comprised of settlers who moved in from other Districts in Zimbabwe while the second generation of settlers was comprised of children of the 1st generation of newcomers. The 1st generation of newcomers held the most per capita wealth especially livestock assets. While 1st generation newcomers comprised 24% of the sample, they owned about half of the livestock wealth. The indigenous settlers were the poorest and their wealth holding was significantly lower than the other two groups. Observing that the 1st generation of settlers was self-selected in terms of immigration, their access to capital and farming experience was above average. Indigenous settlers were going through a learning process of capital accumulation but appeared to lag behind the newcomers.

Gender: Gender appeared to have no association with per capita wealth holding. Female headed households had higher per capita wealth than male headed households, but the differences were not significant at p=.05. Gender literature suggests that female managers are poorer because of institutions that are not sensitive to the plight of female managers. In terms of per capita wealth, female managers were holding as much wealth as male managers.

Family Type: It is commonly perceived that polygamous families are wealthier than monogamous families based on the ability of the husband to attract additional spouses. The evidence from this study shows that polygamous families held significantly less livestock, equipment and land investment wealth per capita. According to data from this study, the conventional perception is only a myth.

Non-Farm Employment: Access to non-farm income is considered important in the ability of households to finance farm capital accumulation (Savadogo, et al 1998). Households without access to non-farm income are hypothesized as less likely to invest in animal traction equipment. In table 2, families with household heads who at one time had been engaged in formal employment had greater wealth holding per capita than those families with household heads who never had such an opportunity. This overall difference is attributed to different levels of investment in livestock wealth. Investments in equipment and land improvements were not significantly different. The effect of non-farm income on wealth holding was reflected in livestock assets.

5.4 Direction and Magnitude of Socioeconomic Mobility

5.4.1 Equipment mobility

Equipment investments by farmers are permanent in the sense that once farmers adopt a particular equipment set, they will keep the equipment over time replacing it as and when needed. As shown in Table 5.3 the mobility over the 10-year period is exclusively positive, suggesting that farmer's equipment asset holdings never decline. For example, all the farmers in the top decile in 1987 maintained that position in 1996. Depreciation in asset value is inevitable with or without use but the adoption of a piece of equipment continued over time. Of the 111 farmers who had zero equipment investments in 1987, about 40% remained in that position in 1996 while 13% made it to the 5th decile and above. Only 1% of the households made it to the top decile. While there were 84 households in the 1st decile in 1987, 53% of these household remained in that position and 23% improved to the fifth decile or higher.

Mobility in equipment investments appeared to be gradual. Big leaps in equipment investments were not common within a ten-year period. Overall, ten years were not adequate to have a full-blown investment in equipment assets. This is particularly the case because farmers self finance these investments given the absence and failure of equipment credit markets.

Table 5.3: Transitional Matrix of Equipment Wealth in Linked Settlers, (1987 – 1996) Gokwe North District, Zimbabwe, 1996.

		1996 DECILES											
1		0	1	2	3	4	5	6	7	8	9	10	N
9	0	.396	.333	.000	.108	.027	.090	.018	.018	.000	.000	.009	111
8	1		.536	.000	.214	.024	.131	.048	.012	.024	.012	.000	84
7	2			.000	.000	.000	.000	.000	.000	.000	.000	.000	0
	3				.444	.000	.139	.278	.083	.055	.000	.000	36
D	4					.273	.273	.090	.090	.090	.000	.182	11
E	5						.555	.222	.111	.111	.000	.000	9
C	6							.400	.500	.000	.100	.000	10
I	7								.428	.286	.143	.143	7
L	8									1.00	.000	.000	2
E	9										.500	.500	2
S	10											1.00	6
N		44	82	0	46	8	34	23	16	10	4	11	278

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Gokwe North, Zimbabwe, 1996-97.

Table 5.5 shows the degree of association between mobility in equipment investments and demographic variables. Settlement tenure appeared not to have any association with mobility in equipment investments. On average, recent and early settlers had all moved one decile from the 3rd to the 4th decile during the period 1987-96. In terms of the tsetse control gradient, areas cleared of tsetse recently were behind in terms of equipment investments. Settlers in mid gradient had moved 2 deciles. The degree of association suggests that investment in equipment may have been impeded by the presence of tsetse flies. There was some association between mobility and settlement status. Indigenous settlers appeared to lag behind other settlers and had only moved one decile while 1st generation migrants had moved two deciles within the same period. In general, newcomers held more equipment to start with and had moved twice as much as the first settlers. While pioneer settlers were catching up with the rest, they were less agriculturally inclined ten or more years ago. Again, settlers who settled before and after tsetse control had achieved a similar magnitude of mobility in equipment investment. Settlers who moved in during tsetse control stood above the rest.

Age appeared to have little association with equipment mobility. Although younger households were in a disadvantaged position in 1987, they had caught up with the more mature households in 1996. The 1996 equipment investment levels had little association with age at that time.

Table 5.4: Average Livestock and Equipment Wealth Positions in 1987 and 1996, Gokwe North district, Zimbabwe, 1996

Group		Equipment		Livestock	
		1987	*1996*	*1987*	*1996*
Sample	278	1.74	3.23	2.34	2.85
Settlement Tenure					
5-10	18	1.06	3.50	1.89	2.72
11-15	97	1.76	3.81	2.10	3.55
16-20	42	1.95	3.26	2.36	2.60
>20	121	1.74	3.23	2.34	2.85
Gradient of Control					
Early	105	2.07	3.02	3.16	1.94
Mid	100	2.06	4.31	1.82	4.08
Late	71	.83	2.09	1.93	2.45
Settlement Status					
Pioneer settlers	136	1.04	2.21	1.40	1.68
2nd generation immigrants	77	2.39	3.71	2.82	3.37
1st generation immigrants	65	2.43	4.80	3.74	4.68
Period of Settlement					
Pioneers	147	1.06	2.20	1.50	1.71
Newcomers	131	2.50	4.38	3.28	4.12
Timing of Movement					
Before Tsetse Control	129	1.65	2.80	2.26	2.61
During Tsetse Control	90	1.96	4.10	2.50	3.79
After Tsetse Control	59	1.61	2.85	2.27	1.91
Age in 1996					
Under 31	10	.80	3.4	.40	1.8
31 – 40	54	1.33	2.98	1.56	2.70
41 – 50	95	1.64	3.18	2.31	3.11
51 – 60	51	2.29	3.73	2.47	2.86
61 +	68	1.93	3.10	3.21	2.67
Family Type					
Monogamous	199	1.81	3.15	2.45	3.06
Polygamous	79	1.57	3.43	2.06	2.33
Employment Experience					
Yes	148	1.82	3.20	2.37	3.16
No	130	1.65	3.26	2.31	2.50

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Gokwe North, Zimbabwe, 1996-97.

Whether a household type was monogamous or polygamous did not affect mobility in equipment investment during the period 1987 to 1996. This was also the case with wage experience. Household heads with formal work experience had advanced equally well in equipment investment as households who had no such experience.

5.4.2 Livestock Wealth Mobility

Livestock assets, unlike equipment, fluctuate in size over time due to sales, deaths (due to drought and diseases) and culls. The results in Table 5 show both positive and negative fluctuations in cattle assets for the two periods under consideration. About a third of the sub-sample used in this analysis had not made any investment in livestock in 1987. By 1996, about 12% had moved to the fifth decile or better. However, 33% had not made any livestock investments in 1996. Half of the households who were in the 1st decile in 1987 remained in that position ten years later and about 8% moved to the fifth decile or better. About 6% of the households who were on the 1st decile in 1987 had not invested in livestock as of 1996. Approximately 40% of the households who were on the 2nd decile in 1987 had advanced to the fifth decile or better in 1996 but a quarter of this group faced declines in cattle wealth. The proportion of declines increased directly with investments. About two thrids of households in the third deciles shifted to lower deciles in 1996. Households who had large investments in livestock had higher chances of facing a decline in livestock assets. Thirty-seven percent of households in

the top decile in 1987 remained in that position while the rest of them declined. Six percent of the households dropped all the way to no investment at all in 1996. The loss could have been voluntary or due to natural causes.

Overall, there was no significant change in cattle holding (Table 5.5) between 1987 and 1996. While cattle herds are expected to grow over a ten-year period, losses were inevitable. Typically, this agro-ecological environment experiences mild to severe droughts at least 4 out of ten years. Besides, cattle are sold to finance large expenditures, for example, school fees and goats provided much needed proteins and ready cash.

Settlement tenure had no obvious association with mobility in livestock investments. While all the small groups of tenure achieved mild boosts in livestock investment in the ten-year period, the tenure groups with less than 15 years had the greatest positive shift. Residents who have been settled for more than 15 years had marginal changes in livestock investment. The association between age of household head and mobility in livestock investments shows a similar pattern.

Table 5.5: Transitional Matrix of Livestock Wealth in Linked Settlers (1987–1996), Gokwe North District, Zimbabwe, 1996.

1987 DECILES	1996 DECILES 0	1	2	3	4	5	6	7	8	9	10	N
0	.329	.318	.125	.057	.057	.068	.023	.011	.000	.000	.011	88
1	.065	.508	.115	.147	.082	.016	.049	.000	.000	.016	.000	61
2	.100	.150	.150	.050	.150	.075	.150	.075	.000	.075	.025	40
3	.111	.444	.111	.111	.111	.000	.055	.000	.000	.000	.055	18
4	.063	.187	.063	.125	.063	.125	.125	.125	.125	.000	.000	16
5	.083	.167	.500	.167	.000	.000	.000	.000	.000	.000	.083	12
6	.000	.125	.000	.125	.125	.375	.125	.000	.000	.000	.125	8
7	.000	.125	.250	.125	.125	.000	.000	.000	.125	.000	.250	8
8	.000	.000	.250	.250	.250	.000	.000	.000	.000	.000	.125	4
9	.000	.000	.000	.500	.000	.250	.000	.000	.000	.000	.250	4
10	.063	.000	.187	.000	.063	.063	.125	.125	.000	.000	375	16
N	42	80	39	27	23	17	17	8	3	4	15	275

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Gokwe North, Zimbabwe, 1996-97.

Young households advanced by more than one decile between 1987 and 1996 while household heads greater than fifty years advanced by less than half a decile. Household heads above 60 years de-invested in livestock assets. This is expected as their period of retirement sets in.The pattern shown by the gradient of tsetse control is surprising. Households in early cleared areas experienced a decline of more than a decile in livestock investments in 1996 when compared to their investments in 1987. Early cleared areas could be more drought prone than other locations where pastures are relatively abundant. In contrast, the other areas experienced an increase in livestock investments especially in the mid control gradient.

The results exhibited a clear pattern of livestock asset positions across settler types. In 1987, indigenous settlers were at the 1st decile, 2nd generation newcomers were at the 2nd decile while 1st generation newcomers were on the 3rd decile. The 1st generation migrants were at an advantage in 1987 because some of them brought livestock at the time they moved in while others brought capital and purchased livestock once they settled-in. Each of these groups moved upwards by one decile maintaining the relative difference among each other.

Variables including household type, and timing of movement did not show patterns of association with livestock assets between 1987 and 1996. Work experience had the expected effect of boosting livestock assets. While all the two groups were in the same decile in 1987, households with formal work experience had shifted upwards to the third deciles but those households without experience remained in the same position ten years later.

5.5 Determinants of Per Capita Wealth

Several associations of per capita wealth with household demographic variables have been discussed. A quantitative assessment of wealth accumulation was performed by regressing per capita wealth on demographic and location variables. The results are presented in Table 5.6. The individual effect of variables after partialing out the effect of other variables is discussed next.

Delay in cattle adoption: The longer the period without cattle adoption in one farmer's tenure the lower was their per capita family wealth, everything else constant. An additional year of settlement tenure spent without cattle significantly reduced per capita wealth by $117. Adoption of cattle was critical to the supply of animal draft needed to boost production factor productivity. Households who had adopted cattle immediately

after settlement had a greater opportunity of accumulating wealth than households who adopted cattle several years after settling-in.

Table 5.6: Results of an Econometric Model for Wealth (Livestock and Equipment) Mobility for Settlers in Gokwe North District, Zimbabwe, 1996.

Explanatory Variables	Per capita total wealth			Wealth Mobility 1987-96		
	Coeff	T-value	Mean	Coeff	T-value	Mean
Years settled before adopting cattle	-117.051	-4.841**	7.88	-138.97	-1.234	12.17
Age at settlement (yrs)	-80.381	-2.625**	29.79	-427.70	-3.697**	28.47
Off-farm (yes =1)	515.567	.832	.48	2594.54	1.032	.53
# of family members completed high school	432.45	2.509**	1.00	-1554.15	-1.842**	.89
Gender (female =1)	192.096	.225	.14	--	--	
Adopted cattle before 1986 = 1	--	--		-9405.61	-2.768**	.48
Farm size (acres)	--	--		413.35	2.943**	16.07
No. of female spouses	-1045	-3.2**	1.34	-1956.82	-1.235	1.37
1st Gen. immigrant =1	2088.63	2.665**	.27	3049.85	.960	.27
Settlement before tsetse control = 1	654.88	.707	.28	-7764.29	-2.441**	.46
Settlement after tsetse control = 1	-1916	-2.502	.48	--	--	.21
Early Cleared Areas	657.97	.912	.32	-9587.98	-2.729**	.38
Mid cleared Areas	3983.95	5.614**	.34	12032.69	3.641**	.36
Constant	9406.91	6.334**		24528.58	3.672**	
Adjusted R^2		.195			.302	
S.E. of estimation		6069			19428	
Sample size		458			271	

Source: Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Gokwe North, Zimbabwe, 1996-97.

Age of Settler at time of settlement: Household heads who had waited for longer periods prior to settling-in were significantly poorer. For each year old delay, per capita wealth decreased by $80.38 *ceteris paribus*. Household heads spending longer time periods in other locations were disadvantaged. The experiences obtained elsewhere prior to settlement appeared irrelevant to wealth accumulation in the current settlement area.

Employment experience: The impact of non-farm work experience had the expected impact in wealth accumulation. Household heads with formal work experience were wealthier than household heads without such an experience. Non-farm work experience positively contributed $515.57 per capita, everything else constant. While crop surpluses provide the primary source to finance capital accumulation, non-farm income is critical for financing lumpy investments, for example, cattle and draft equipment. However, the extent of the impact on per capita wealth holding was insignificant.

Education: Households with higher levels of education were wealthier than their counterparts. An additional household member who had completed secondary education made the household per capita wealth increase by $432.45, everything else constant. Individuals with secondary education certificates were employable and could remit part of their earnings or help finance seasonal inputs and farm capital accumulation.

Gender: Gender did not have the expected impact on wealth holding. Female-headed households had higher per capita wealth than male headed households but the differences were insignificant. The evidence does not support the general conception that female-headed households are vulnerable and poor.

Polygamy: Families practicing polygamy were significantly poorer than monogamous households. A family with more than one female spouse had $1045 less wealth per capita, everything else constant. This evidence challenges the conventional wisdom that polygamous households are wealthier. The results show that, on a per capita basis, single spouse families were wealthier.

Immigrants: 1st generation immigrants were wealthier than all other settlers, everything else constant. Settlers who abandoned their previous settlement held $2088 more wealth than settlers who had established their first settlement site in Gokwe North district. Since the migration of the first generation of immigrants was voluntary and unsupported by government, the group was self-selected in terms of wealth holding. Only those immigrants with ability and potential to succeed migrated.

Timing of settlement: Settlers who moved in prior to tsetse being controlled were not wealthier as expected. Generally, settlers with longer tenure are expected to be wealthier

but the results partly contradict that thesis. Settlers who moved-in during tsetse control were not significantly different in per capita wealth holding with settlers who moved in prior to tsetse control. However, settlers moving in after tsetse control significantly held $1916 less per capita wealth than settlers moving in during tsetse control. This part of the results gives support to the conventional thesis. The presence of tsetse flies appeared to take away the premium of early arrival.

Tsetse control gradient: The tsetse control gradient was an important predictor of per capita wealth holding. Settlers in recently cleared areas held significantly less wealth. As mentioned above, the presence of tsetse flies limit the ability of the household to accumulate farm capital.

5.5 Determinants of Livestock and Equipment Asset Mobility

A sub-sample of households who settled in Gokwe North before 1987 was used in measuring the physical change in asset position between 1987 and 1996. Econometric results of livestock and equipment asset mobility are shown in Table 5.6.

Years Settled Before Adopting Cattle: Lengthy delays in adopting cattle after settlement had a negative impact on mobility. On average settlers adopted cattle 12 years after

settlement. Further delay by an additional year reduced household mobility by $139. The effect of this impact was not significant.

Age at Settlement: Individual household heads who settled at a more mature age did not change their asset their asset position as much as those who settled when they were young. The average age at settlement was 29. Settling at an age one additional year older than average contributed a reduction in household mobility of $427, everything else constant. This impact was significant at p= .05. More mature settlers were not expected to change their asset position significantly once they had passed the stage of wealth acquisition in their life cycle.

Off-farm employment experience: While formal employment experience contributed positively to asset mobility, the impact was not significant. Non-farm income gives the household an additional source of finance for capital investment but these activities may reduce the amount of labor available for farm activities. The net effect did not make significant impact on household asset mobility but the direction of impact was as expected.

Education: A higher number of household members who completed secondary education surprisingly contributed to less asset mobility. The trade-off between education and farm assets was significant. Everything else constant, an additional member who completed

secondary education reduced household mobility by $1554. Households often liquidate their livestock assets to raise cash to pay school fees. Unless the candidates do well in school and get employed, the payoff to such de-investment is negative.

Cattle Adoption before 1986: About 48% of the settlers had adopted cattle before 1986. However, adoption of cattle prior to 1987 was associated with de-investment in assets. Between 1986 and 1996, there were three or four years of drought. It is expected that the livestock asset position in 1996 was much worse than was the case in 1986. This contradicts conventional understanding that smallholder herd sizes will increase uncontrollably putting unbearable pressure on pastures. Drought seasons especially in 1994/95, decimated cattle herds and as of 1996/97, pastures were abundant.

Farm Size: The size of the farm played a significant role in asset mobility. Settlers with an additional hectare of land advanced their asset position by $413, everything else constant. Settlers operating a larger than 6.5 ha farm were inclined to mechanize in order to manage larger cropping areas. Resourceful settlers were expected to advance rapidly and in a bigger way than less resourceful settlers.

Number of female spouses: Households with more than one female spouse advanced much less than households with one female spouse. However, the effect of polygamy on

asset mobility was insignificant. The ability of polygamous families to invest in productive capital is limited by the excessive demand for food and other basic needs associated with bigger households.

Settler Status: While 1st generation immigrants advance their asset position higher than other settlers, the effect was not significant. The opportunity to advance was open to all types of settlers. This result suggests that, agricultural frontier areas are equally open to the advance of all types of settlers.

Settlement timing: Settlers who moved in before active tsetse control began did not advance as much as those households who moved in with tsetse control. Moving in prior to tsetse control led to a reduction in asset position of $7764, everything else constant. Despite having much advanced knowledge of local conditions tsetse settling in tsetse infested areas eliminated the benefits associated with early settlement.

Tsetse Control Gradient: The gradient of time since tsetse control was an important predictor of asset mobility. Settlers who occupied areas cleared of tsetse flies early had the least change in mobility. Other settlers who moved into areas cleared in the mid-period had the greatest asset change. Advancement was expected to be greater during the 1st ten years after tsetse fly control than later on. The first ten years after tsetse control,

farming systems change substantially as households make livestock and equipment investments for the first time. After the first ten-year period, the only additional change is expected to be incremental.

CHAPTER 6: DISCUSSION AND CONCLUSIONS

6.1 Tsetse Control and Migration

Tsetse control had a direct effect on immigration but did not motivate emigration. The main motivation for emigrating was to acquire adequate arable land. In addition to tsetse control, other factors including the end of war and access to public transport positively impacted on immigration. The results are summarized as follows:

1. Rural -to-rural movements of households was a common occurrence over the past few decades. The historical racial imbalance in land distribution is responsible for instituting regional imbalances in land access leading to overcrowding and subsequently emigration.

2. Tsetse control helped in the immigration of households who were moving in with their cattle. Motivated primarily by the desire to acquire good and abundant land, immigrants without cattle even settled in tsetse infested areas.

3. Immigration into Gokwe North occurred in trickles prior to Zimbabwe's Independence. In the five years following the end of the war, the largest flow of immigrants into Gokwe North occurred. Apparently there was a strong feeling at that time that access to land was one of the rights people fought for.

4. Immigrants considered primary roads as important physical infrastructure. Good roads attracted private investments in commuter and commodity transport and allowed communication with other trading centers in the country. Other services including schools, clinics and consumer stores were desirable but were not necessary at the time of immigration.

Nineteen years after independence, the Zanu(PF) government had not committed itself to a comprehensive program of rural resettlement. The existing structural features of land tenure gave the best land to Whites and a few well connected Blacks. Much of the land given to Blacks could not support them without urban remittances. So Blacks were always looking for better land. Newly available land was attractive even if it had tsetse flies. Whether immigrants anticipated tsetse control when they moved into settlements with tsetse flies is a moot point. Settlers who did not own cattle at the time of migration appear to have been less concerned about the presence of tsetse and trypanosomosis. Those settlers who moved in with cattle settled in areas with tsetse and trypanosomosis control.

Unless government redistributes land and continues to tolerate voluntary unassisted settlement, rural households are predicted to continue moving into areas with relatively better farming opportunities.

Immigration into the Zambezi Valley reflects on problems encountered elsewhere in non-contiguous districts. To successfully manage immigration in the Zambezi Valley, land-use problems and lack of opportunities in other communal areas need attention. Attention to economic development problems in the sending areas will help in balancing economic opportunities across districts and dampen migration. To tackle development and environmental problems in the Zambezi Valley requires a wider perspective beyond the location of the valley.

6.2 Farming System Change With Tsetse Control and Immigration

Another story emanating from this study is that immigrants and tsetse control were strong positive forces for agricultural development in Gokwe North. Results from Chapter 4 can be summarized as follows:

1. Immigrants can be considered as innovators in breeding cattle for animal traction within Gokwe. This group of settlers wanted to pursue the type of mixed farming system they practiced in their areas of origin. So some immigrants in-migrated with their cattle while others purchased cattle once they had settled. Pioneer settlers in Gokwe North were catching up on operating mixed farming enterprises.

2 Despite the disease risk and livestock movement restrictions, there was as much cattle adoption in each village with and without active tsetse control. Cattle adoption in tsetse infested areas was possible to the extent that cattle owners could access and use drugs provided free by the Department of Veterinary Services. When cattle were introduced in Gokwe North, tsetse flies were present but drugs were accessible.

3. The average growth rate in cattle adoption per village between 1960 and 1996 was negative and significant. The negative growth suggests that non-adopting households had limited financial resources and access to livestock credit markets. Commercialization of production was critical to overcome liquidity constraints and allow self-financed investment in capital formation. A shift of producer price balance in favor of cash crops provided incentives for cattle adoption.

4. Ox owners and renters had different pathways available to them for improving productivity. The avenue for intensifying productivity for ox owners was through employing additional units of labor and land. The avenue for intensifying productivity for ox renters and hand tillers was through additional investment in physical capital. Hand tillers were close to their productivity

limit. To improve factor productivity among hand tillers, investment in farm capital intensification was needed. Access instead of ownership of animal traction technology was all that mattered.

The presence of tsetse flies had made cattle adoption difficult but the fly presence did not preclude the introduction of cattle into the study sites. This lays credence to one suggestion that tsetse control operations were targeted at locations with the highest incidence of trypanosomosis in cattle instead of the degree of tsetse fly infestation *per se*. This strategy was adopted to keep the cost of administering drugs low for the exchequer.

Given the absence or underdevelopment of well functioning livestock credit markets, cattle adoption was predominantly self- financed. The linkages between cotton production and adoption of animal traction were more expansive than what is generally acknowledged in the literature. Without off-farm employment, non-cotton growers were less likely to adopt cattle. Extension programs that encourage use of animal traction cannot be implemented without targeting the technology on high value crops like cotton. The least cost and short term approach to improve capital intensification among hand tillers was to develop a market for custom ploughing service and introducing minimum tillage practices.

6.3 Wealth Distribution and its Determinants

Chapter 5 examined wealth distribution in 1996 and wealth accumulation from 1987 to 1996, focusing on the influence of household demographic and regional factors. The results can be summarized as follows:

1. The aggregate distribution of wealth was fairly even while livestock and equipment wealth were unevenly distributed. Investment in livestock was not risk-free. Unlike equipment investment, livestock investment was risky.

2. The age profile of wealth accumulation supported the life cycle hypothesis. Young households had the least wealth as they were still settling in and striving to establish food security. Middle-aged household heads were the wealthiest. The elderly households were nearing or already in retirement and their asset position was declining after years of accumulation.

3. The length of residential tenure did not have the expected effect on wealth accumulation. Early arrival before tsetse control did not result in the expected premium in wealth accumulation. The presence of tsetse flies eliminated the premium associated with early arrival.

4. The conventional wisdom suggesting that polygamous households are wealthier than monogamous ones was a myth. When looked at on a per capita basis, monogamous households were wealthier than polygamous households. In addition, female-headed households were among the better off households.

5. The greatest wealth improvement was observed in those areas that had recent control relative to the period under scrutiny. There was more wealth acquired within the first 10 years after tsetse control than 10 – 20 years after tsetse control. The first ten years after tsetse control featured substantial changes in the farming systems associated with livestock and equipment investment. The farming systems only changed incrementally after the first ten years of settlement.

The school of thought linking agricultural frontier areas with socioeconomic equality is not rhetoric in an aggregate sense. The opportunities for socioeconomic advancement in the settlement frontiers were fairly equal among all settlers. Agricultural frontier areas, therefore, have potential to contribute positively to redistribution of wealth throughout the country. The difficulty of achieving more equal wealth distribution over time could be eased through a managed program of internal migration or resettlement. The government can propel such a process in high potential areas in order to improve the balance of socioeconomic welfare

throughout the country. This is in line with government efforts of resettlement. The opportunities for acquiring wealth appeared to be gender sensitive.

6.4 Limitations of the study

While some attempt was made to control for access to infrastructure services at the time of the survey, there was need to accurately determine the actual time of development. Since more than 90% of the households settled before 1996, the infrastructure services available in 1996 did not affect their choice of settlement site before that year. A time-line of service development of each village was required to comprehensively measure the impact of these services on the flow of immigrants. Besides, the physical locations of settlement sites and service sites could have been captured with a geographical position system (GPS) and data included in the model.

Additional attention could have been given to the process of emigration from Gokwe North District rather than focusing entirely on immigration. The records would have been difficult to capture at the village level since local leaders do not keep physical records of who left. With some help and time, most village-heads can construct a settlement profile for their jurisdictions with reasonable accuracy. While aggregate data is available at the district level, its usefulness is limited for local assessments.

In attempting to measure the impact of tsetse and trypanosomosis control, it is important to have a good measure of the variable under scrutiny. Getting a good measure of the degree of tsetse challenge and trypanosomosis risk representative for the study sites was a daunting challenge. Ideally, sites with good data should have been targeted for selection. The Tsetse and Trypanosomosis Control Branch conduct pre and post-control surveys of tsetse fly specie and their prevalence. In addition, a sister branch conducts trypanosomosis surveys. Data on positively identified cases of trypanosomosis could provide a reasonable measure of the degree of trypanosomosis risk for a particular location and time. However, the data were not collated and the data formats changed over time making it not readily useable. Livestock census data over the years could also provide a mirror image of the impacts of trypanosomosis. The department of Veterinary Services collects livestock census data including productivity parameters. The challenge in handling this data is that the unit of observation has consistently changed over time.

Household socioeconomic mobility can be defined in many ways besides accumulation of physical assets. This study failed to capture the investment made in human capital in terms of education for the parents and children. Resources spent in paying school fees and attending school have a high opportunity cost and need to be accounted for in measuring wealth accumulation. In addition, the study failed to assess how many household members were

employed elsewhere or what was the degree of non-farm participation for each household and how much net cash savings they had accumulated.

6.5 Areas for Further Research

Tsetse control efforts were very successful in removing the vector and facilitating the development of mixed farming systems. Yet tsetse control affect other issues. Tsetse control agencies have neglected land-use and environmental effects of activities occurring during and after tsetse control. Apart from direct ecosystem impacts, there are concerns about resource degradation due to uncontrolled and haphazard settlement and land-use. Coordination of human and livestock movement into tsetse controlled areas is lacking. With a slow paced government resettlement program, there are few choices of where people can settle. Making voluntary-unassisted settlement illegal may keep people from emigrating but may lead to serious problems of starvation. At the same time, uncontrolled immigration and land-use can lead to short term gains but may cause a long term environmental disaster. What is crucial is recognizing that tsetse control on its own is only a partial development vision. How can public and private investments be sequenced in order to promote development of the agricultural sector.

Often, migration studies conduct surveys in destination areas and neglect the areas of origin. When assessing the welfare impacts of migration, the incidence of impacts could be

broadened to include source areas. Such an approach enables a more holistic assessment of the impacts of migration to the nation as a whole. As was the case in this study, a significant proportion of the immigrants where from neighboring districts. Future studies could devote resources to study related processes in areas adjacent to the primary survey site.

A lot of controversy still revolves around the profitability and impact of animal traction on labor and land productivity. Capturing the profitability of animal traction investment requires capturing the input and output data of all the activities where animal labor is deployed. Focusing on one particular enterprise for a given season would not provide a comprehensive measure of the returns to investment. The most challenging aspect of such work is capturing the animal and human labor hours and purchased inputs for a particular activity. The resources required to do this work are immense but necessary to answer the questions.

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