ASSESSMENT OF LIVESTOCK FARMERS' PREFERENCES FOR INTEGRATION OF COMMUNITY-OWNED RESOURCE PERSONS AND INTERRELATIONSHIPS IN ANIMAL TRYPANOSOMIASIS MANAGEMENT METHODS IN KWALE COUNTY, KENYA

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DECLARATION

This thesis is my original work and has not been presented for an award in any other university.

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DEDICATION

To my parents Ursula and Stanislaus Lumumbah, my brothers Rufus and Augustine and my sister Flavia, I dedicate this thesis to your unconditional love, encouragement, and endless support.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AAT	African Animal Trypanosomiasis
ASALs	Arid and Semi-Arid Lands
ASDS	Agriculture Sector Development Strategy
AU	African Union
CA	Conjoint Analysis
CE	Choice Experiment
CORPs	Community-Owned Resource Persons
CS	Compensating Surplus
CVM	Contingent Valuation Method
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussion
FITCA	Farming in Tsetse Controlled Areas
GDP	Gross Domestic Product
HAT	Human African Trypanosomiasis
ICIPE	International Centre for Insect Physiology and Ecology
IIA	Independence of Irrelevant Alternatives
IMF	International Monetary Fund
ITC	Insecticide Treated Cattle
ITT	Insecticide Treated Traps
KENTTEC	Kenya Tsetse and Trypanosomiasis Eradication Council
MNL	Multinomial Logit
OECD	Organization for Economic Co-operation and Development
PATTEC	Pan African Tsetse and Trypanosomiasis Eradication Campaign
RP	Revealed Preference
RPL	Random Parameter Logit
RUT	Random Utility Theory

SAPs	Structural Adjustment Programs
SAS	Sequential Aerial Spraying
SIT	Sterile Insect Technique
SLL	Simulated Log-Likelihood
SP	Stated Preference
SSA	Sub Saharan Africa
TLU	Tropical Livestock Units
UN	United Nations
WHO	World Health Organization
WTP	Willingness to Pay

ABSTRACT

Animal trypanosomiasis is a major constraint to livestock production and a threat to food security in most parts of sub-Sahara Africa (SSA). Smallholder cattle producers are particularly affected because access to veterinary services is limited in most cases. While efforts have been made to control the spread and prevalence of the disease in Kenya, the disease continues to cause losses to livestock producers. These losses include reduced meat and milk off-take, weight loss, reduced traction power of oxen, increase in calf mortality and overall cost of livestock management. Subsequently, with the current insufficient veterinary services in the country, farmers in endemic areas resort to presumptive and indiscriminate drug administration thus increasing the risks of drug resistance. The International Centre of Insect Physiology and Ecology (ICIPE) and other partners have recently proposed the integration of communities into trypanosomiasis control methods and programs in Kenya through creating a pool of community-owned resource persons (CORPs) to address the weak extension and veterinary system, facilitate transfer of new control technologies within communities and ensure continuity of donor-funded African animal trypanosomiasis (AAT) management programs. However, the desired attributes of the CORPs by farmers are not known. Further, it is envisaged that successful integration of CORPs rests on the substitutability and (or) complementarity of the current AAT management methods, which is also not established in the existing literature. To address these gaps, this study applied a multivariate probit (MVP) technique to establish the interrelationships in the existing multiple AAT management methods and choice experiment (CE) to determine the farmers' preferences and willingness to pay (WTP) for CORPs' attributes using insights from 5 focus group discussions (FGDs) and survey data from 308 randomly selected cattle keeping households in Kwale County, Kenya. The random parameter logit (RPL) was used to analyze the

CE data. Results showed that farmers are currently using a combination of various methods to manage the disease. The MVP analysis revealed that the multiple AAT management methods used by farmers are complementary and not substitutes. Further, households' socio-economic and institutional factors had varied effects on their choice of multiple AAT management methods. With regard to the integration of CORPs in AAT management programs, the RPL analysis indicated heterogeneous and high preferences for CORP attributes. Results show that farmers had a significant positive preference for relatively younger and male over older and female CORPs. Similarly, the respondents preferred CORPs who are resourceful in the community and whose recruitment is done in a participatory process involving the community. However, there was a higher preference for CORPs trained by non-governmental organizations (NGOs) and development partners such as ICIPE over those trained by the county government. The findings showed that farmers were willing to pay significant amounts of money for these attributes. Further, an analysis of compensating surplus (CS) revealed that different segments of the farmers were significantly willing to pay premiums ranging from 14 percent to 48 percent of their average monthly incomes for the integration of CORPs in AAT management programs. The results from this study instill hope in sustainable AAT management in Kenya and other parts of SSA through promoting the adoption of multiple complementary AAT management methods. The results also provide key insights for integrating local communities in sustainable AAT management programs based on the desirable attributes of the CORPs.

Keywords: Animal trypanosomiasis, integrated management, CORPs, livestock, Kenya.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

The livestock sector is a major player in the global economy with wide-ranging socio-economic impacts, especially on job creation and food supply. As a result, it appeals to policymakers on poverty alleviation strategies. The World Bank (2015) estimated that a half of the 900 million extreme poor people in the world depend directly on livestock for their livelihoods. The sector also accounts for about one-third of the global agricultural gross domestic product (GDP) and 15 percent of the total GDP in sub-Sahara Africa (SSA) (FAO, 2016). Most recent simulations reveal that the total demand for livestock products in Africa is expected to almost quadruple by 2050, in large part to help feed the over 1.2 billion more people projected to be added to the continent during that time (FAO, 2017). In Kenya, the sector employs close to 50 percent of the agricultural labor force and it is a primary source of livelihoods for the majority of the rural population. Further, the livestock industry accounts for 12 percent and 40 percent of Kenya's national and agricultural GDP respectively (Republic of Kenya, 2017). Therefore, the growth in the livestock sector presents enormous opportunities to smallholder farmers.

Livestock production, however, is largely constrained by multiple policy, institutional and natural challenges despite the revolution in the industry as projected by Delgado (2001). The World Bank (2009) warned that the neglect of smallholder livestock production in public policy excludes livestock producing communities from the benefits of growth in the sector in SSA. Animal diseases, on the other hand, have significantly contributed to low production and losses to pastoralists and thus inhibiting the realization of livestock's full commercial potential (Swallow, 2000). The economic implications of livestock diseases include reduced milk and meat productivity, low stock birthrates and rising stock mortality rates with a long-term

implication of reduced herd size and limited diversity of stock composition (Swallow, 2000; Adamu *et al*., 2017).

African animal trypanosomiasis and its vectors, mainly tsetse, and drought are rated as the major constraints to cattle production in SSA (Alemayehu *et al*., 2012). The epidemiology of AAT and its effects on cattle production depends on the prevalence and spatial spread of the disease and its vectors in the affected geographical region (Shimelis *et al*., 2011). As a result, AAT is central to the current policy debate on the fight against poverty in agro-pastoral communities as it is endemic in more than thirty countries in SSA (FAO, 2017). Probably more than any other disease affecting both livestock and people, AAT is a major threat to food security in most parts of SSA.

It is estimated that one-third of the nearly 165 million cattle in Africa are kept in tsetse-infested areas and are at risk of contracting AAT (FAO, 2011). The Smallholder cattle producers are particularly at the receiving end because of limited access to veterinary in many parts of SSA (Specht, 2008). In Kenya, approximately 23 percent of the country is infested by tsetse with 38 out of 47 counties experiencing the threat of trypanosomiasis (KENTTEC, 2018). Therefore, as noted by Meyer *et al*. (2018), addressing AAT threats to livestock production would tremendously improve overall economic benefits to livestock producing communities in Kenya and other endemic regions in SSA.

Veterinary extension services are generally insufficient and unreliable in SSA. Consequently, most farmers often resort to presumptive and indiscriminate self-administration of drugs without professional diagnosis and guidance on dosage calculation, thus unknowingly and unwillingly increasing the risks of drug resistance (Geerts *et al*., 2009). The threat of drug resistance is evident as Delespaux *et al*. (2007) officially reported trypanosomiasis drug resistance in 17

African countries (Burkina Faso, Cameroon, Central African Republic, Chad, Ethiopia, Guinea, Ivory Coast, Kenya, Mali, Mozambique, Nigeria, Somalia, Sudan, Tanzania, Uganda, Zambia, and Zimbabwe). Tsegaye *et al*. (2015) revealed that the number has increased to 21 African countries.

While efforts have been made to control the spread and prevalence of AAT in Kenya; for instance, through the use of traps, repellents, and drugs, the disease continues to cause losses to agro-pastoralists (Holt *et al*., 2016). This has resulted to a significant reduction in production and productivity through reduced milk yield, weight loss, spontaneous abortions and reducing the traction power of oxen. Reduction in efficiency and traction power of oxen significantly reduces household disposable income as the animals are a vital source of household on-farm and off-farm labor in SSA (Swallow, 2000).

Of the available tools and methods for control of *tsetse* and AAT, traps and repellent collars, which are perceived as better alternatives, have not been fully embraced, leading to overreliance on drugs by farmers (Saini *et al*., 2017). Therefore, to improve the uptake of alternative AAT management technologies, and reduce the inappropriate and indiscriminate use of drugs, development partners and research organizations are advocating for an integrated approach. For instance, ICIPE is leading an experimental initiative that is anchored on strong community partnerships and engagements for sustainable management of tsetse and AAT.

In the approach, community-owned resource persons (CORPs) are proposed by ICIPE as a resourceful tool for establishing and strengthening community partnerships and building local acceptability and ownership of disease control programs. The engagements through CORPs could facilitate the provision of necessary and tailored skills to agro-pastoralists, which they could use independently with minimal professional support in the control of trypanosomiasis. A

similar approach was successfully adopted in malaria vector control in Tanzania (Chaki et al, 2011). Most importantly, the CORPs could impart skills and technical know-how among the pastoralists on proper and efficient use of emerging technologies such as tsetse traps, repellent collars, and also minimize cases of inappropriate drug administration and AAT drug resistance.

1.2 Statement of the research problem

According to KENTTEC (2018), 38 out of 47 counties in Kenya are under threats of tsetse and AAT. Kwale county is among the most affected because of its proximity to Shimba Hills national park where wild animals such as elephants are the main hosts of tsetse (McCord *et al*., 2012). Animal trypanosomiasis is inhibiting the region's massive agricultural potential both in crop and cattle production.

Further, insufficient veterinary and extension services in Kwale county has worsened the situation. As a result, farmers lack the required skills to integrate new tsetse and trypanosomiasis control technologies in their control practices. For instance, ICIPE with other stakeholders developed an affordable tsetse repellent collar which was proved to be effective in reducing tsetse bites in livestock by 94 percent (Bett *et al*., 2015) and reduced prevalence of AAT by over 80 percent and drug (trypanocide) use by 60 percent (Saini *et al*. 2017). However, despite its substantial potential, most farmers were not conversant enough with this technology. Additionally, with insufficient veterinary services, livestock producing households have resorted to presumptive and indiscriminate drug administration which is associated with high cases of drug resistance within their herds, hence sabotaging the control efforts. The current control programs are also believed to be heavily reliant on donor funding thus limiting their sustainability once the donor support ends.

An integrated approach is proposed by *ICIPE* and other development partners to address the aforementioned gaps and challenges. This approach calls for the involvement of local communities in trypanosomiasis control programs. The main idea is to recruit and train a pool of resource persons from the community known as community-owned resource persons (CORPs). These CORPs will bridge the gaps in existing AAT management methods and programs by facilitating AAT control knowledge, skills and technology transfer. Besides, the CORPs will be an integral part of ensuring the sustainability of donor-funded trypanosomiasis control programs. Notably, it is envisaged that the successful integration of CORPs in existing control methods and programs will largely depend on the interrelationships (complementarity or substitutability) in the existing control methods. However, farmers' desired attributes for these CORPs are unknown. Further, the interrelationships among the existing AAT control methods are also unknown. Previous studies analyzed the adoption behavior of control methods independently, which excludes key economic information in a real situation when farmers are faced with multiple options. Therefore, a detailed understanding of these issues will be important for an ex-ante design of an efficient and sustainable integrated approach in the programmatic control of trypanosomiasis in Kenya and the rest of the developing world.

1.3 Objectives of the study

The overall objective of the study was to assess the livestock keeping households' preferences for the integration of CORPs in the trypanosomiasis management programs in Kwale county, Kenya.

The specific objectives were to:

i. Characterize existing trypanosomiasis control methods.
ii. Analyze interrelationships among existing trypanosomiasis control methods.

iii. Estimate farmers' preferences and WTP for attributes of CORPs to be integrated into AAT management programs.

1.4 Research hypotheses

i. The existing trypanosomiasis control methods are not interrelated.

ii. Farmers do not prefer and are not WTP for any of the attributes of a CORP to be integrated into AAT management programs.

1.5 Justification of the study

The CORPs hold a massive potential in addressing the weak veterinary extension services in Kenya. The findings from this study will enhance stakeholder ownership and acceptability of AAT control programs through a bottom-up approach to consensus building.

Kwale County's 2018-2022 integrated development plan, section *2.2.3.5* identifies pests and diseases as the major challenges to agricultural production and productivity. Section *2.2.6* seeks to bring the community on board through public participation in making sustainable policies that will address the County's development issues. Agro-pastoralism being the residents' main source of livelihood and a potential pathway out of poverty, policies in the sector affect them directly or indirectly. Therefore, it is necessary to engage the community in designing and implementing such policies.

The results from the study will also contribute to the realization of Kenya's vision 2030 in which agriculture is a critical component of the economic pillar. Additionally, the study will significantly contribute to the achievement of Kenya's agricultural sector development strategy (ASDS) 2010-2020 whose section *5.2* identifies animal zoonotic diseases and pests coupled with inadequate technical capacity for disease control as constraints to the livestock sector. Section

5.2.2 of the ASDS seeks to address these constraints through integrated approach to disease control and management.

Finally, this study is consistent with the first and second global sustainable development goals (SDGs). These goals seek to end extreme poverty in all forms and to end hunger, achieve food security and improved nutrition and promote sustainable agriculture respectively. The integration of CORPs is a sustainable approach in the management of trypanosomiasis.

1.6 Study area

Figure 1 shows the map of study arear, Kubo South Ward, Kwale County of Kenya.

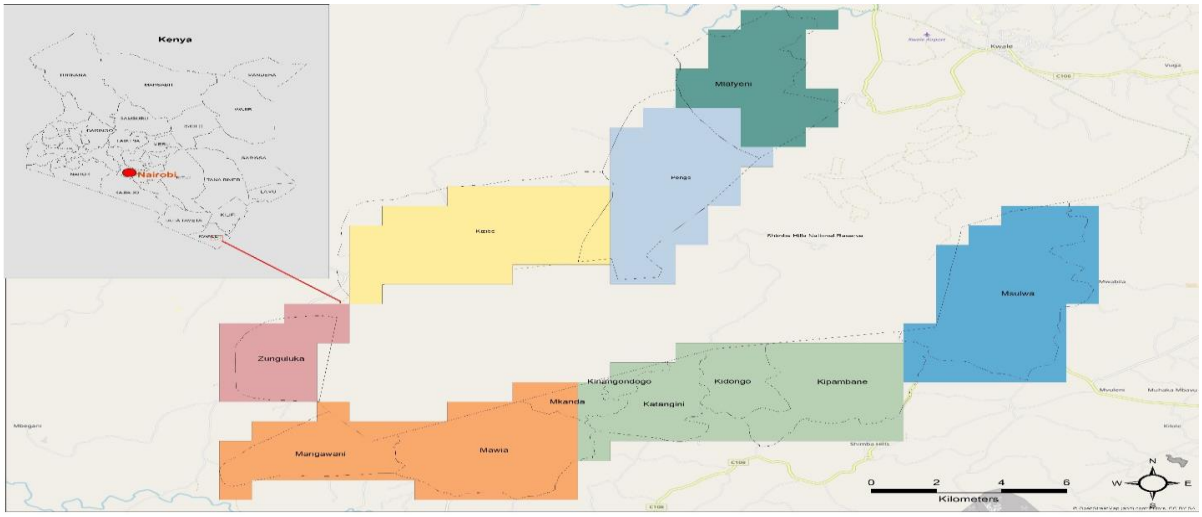

Figure 1: Map of Kubo South in Kwale County, Kenya
Source: ICIPE (2019).

The ward is subdivided into 12 experimental blocks, all surrounding Shimba Hill national game reserve. Each block comprises of atleast two villages making them a more ideal experimental unit. Crop farming and livestock keeping are the main economic activities in the Kubo South, contributing over 80 percent both directly and indirectly to the livelihoods of the community. Cattle, sheep, goats, and chicken are the main types of livestock kept by farmers in this area. Most households own a few local cattle breeds that provide traction for ploughing land,

transporting goods (including water) and a source of food, mainly meat and milk. Crop farming in the area includes fruit farming with coconut, mangoes, passion fruits, cashew and citrus as the most dominant, and food crop farming which include maize, cassava, sweet potatoes, peas, and green grams. However, despite the huge agricultural potential, AAT, a life-threatening neglected tropical disease that affects cattle, goats and sheep is endemic to this region, a resource-poor setting inhabited by smallholder farmers. Furthermore, the County government of Kwale, in its 2019-2022 strategic development plan, recognizes that even though there is high production potential for both crops and animals, the current yields are constrained by AAT.

1.7 Organization of the thesis

This thesis is organized into six chapters. Chapter one provides a background on the economic importance and challenges to livestock production, mainly AAT. The research problem and the objectives of the study are also presented in chapter one. Chapter two contains the literature review on the economic implications of AAT, the existing management methods, review of the role of local communities in livestock disease management, policy and institutional constraints and review of analytical methods. The chapter also contains conceptual and theoretical frameworks. Chapters three, four, five are presented in paper format each representing objectives 1,2 and 3 respectively. Chapter six is the final chapter and it provides a summary of the study, main conclusions, policy implications, and suggestions for further research.

CHAPTER TWO: LITERATURE REVIEW

2.1 Animal trypanosomiasis incidence and its economic impacts in SSA

African animal trypanosomiasis is prevalent in 37 African countries covering approximately one-third of Africa's total land area and it is a threat to approximately 50 million cattle (Coustou *et al*., 2012; FAO, 2019). The disease has severely affected agricultural productivity and household incomes in most of parts SSA (Bett, 2008; FAO, 2012). Swallow (2000) estimated a 20 percent production loss in cattle across a range of parameters, including mortality, calving rate, draft power, meat and milk production. Chanie *et al*. (2013) also noted that in Ethiopia 95 percent of the households directly attributed reduced meat and milk off take, increased calf mortality and increased cost of livestock management to AAT. Besides, AAT also resulted to indirect losses to farmers. These included decrease in crop production and reduced work efficiency of the animals. The losses are projected to increase over years if sustainable control strategies are not put in place. Tsetse and AAT further limits the optimal use of land for crop production by reducing the potential of draft animals to plough agricultural land. For instance, Holt *et al*. (2016) established that farmers in Burkina Faso, Cameroon, Ethiopia, Uganda and Zambia incurred financial losses due to reduced draft power.

Swallow (2000) noted that unlike animals kept in trypanosomiasis-free areas, those in endemic regions have lower calving rates, lower milk yields, higher rates of calf mortality, and farmers incur higher treatment costs. At the herd level, trypanosomiasis reduces milk sales, live animal offtake and the work efficiency of oxen used for cultivation. Trypanosomiasis also affects human settlements, livestock management strategies and herd size (Ilemobade, 2009). In the tsetse-infested areas as a whole, trypanosomiasis reduces the offtake of meat and milk by at least 50 percent.

Generally, AAT reduces yields, area cultivated, and the efficiency of resource allocation thus diminishing the rural households' incomes and exposing them to food and nutrition insecurity (FITCA, 2005; Feldmann *et al*., 2005). Control of AAT, thus, appears to be more beneficial to the rural communities in SSA where there is high potential for crop-livestock farming systems.

2.2 Challenges and gaps in existing trypanosomiasis control methods

Extensive trypanosomiasis and tsetse (T&T) control operations have been ongoing since the beginning of the 20th century. However, tsetse infestation in the SSA region has hardly receded (Meyer *et al*., 2016). At the beginning of this century, Allsopp (2001) noted that T&T control operations were only covering 1.3 percent of the tsetse-infested area in SSA. In areas without effective vector control, trypanocides are widely used to control AAT in cattle. However, over-reliance on these drugs has led to increased cases of resistance to the existing (Geerts *et al*., 2009).

Since 2000, there has been renewed interest and funding committed to AAT control, as well as research into drug discovery and novel control methods (Scoones, 2014). In addition, the Pan-African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC), whose coordinating office is supported by the African Union (AU), has set tsetse and AAT elimination as its goal.

The PATTEC was initiated in 2000 during the 36th meeting of the AU with a primary objective of making the African continent free from tsetse flies, by using an area-wide approach. Phase I of the PATTEC campaign, named "Creation of Sustainable Tsetse and Trypanosomiasis free areas in East and West Africa", targeted three countries in West Africa: Burkina Faso, Ghana and Mali and three in East Africa: Ethiopia, Kenya and Uganda (Kabayo, 2002). These regions were chosen owing to their high agricultural potential (Feldmann *et al*., 2005).

The PATTEC initiative sought to employ an area-wide approach that integrates a variety of tsetse suppression methods, including traps, insecticide-treated targets, application of ultra-low volume insecticides by aerial or ground spraying and the sterile insect technique to achieve total elimination of tsetse and trypanosomiasis. However, despite these efforts, T&T is still endemic in more than thirty countries in SSA (FAO, 2018).

Over time, more ecologically and administratively acceptable methods have been developed such as selective bush clearing, sequential aerial spraying (SAS), insecticide-treated traps and targets (ITT), insecticide-treated cattle (ITC) used as live baits and eventually the sterile insect technique (SIT) (Vreysen *et al*., 2012). More recent studies show that restricted applications of insecticides on cattle are a cheaper control option but their effectiveness could be compromised by the farming communities' lack of skills in applying these methods (Bouyer *et al*., 2009; Muhanguzi *et al*., 2015).

The Farming in Tsetse Controlled Areas (FITCA) program was implemented from 1997 to 2004 in East Africa. With financial support from the European Development Fund, it operated in Kenya, Uganda, Ethiopia and Tanzania. Initially it made use of targets and traps set up by government officials, followed-up with insecticide treatment of cattle. The project also encouraged the use of zero grazing dairy units protected by insecticide-treated nets (Bauer *et al*., 2006). As the program emphasized the involvement of communities in T&T control, it assisted groups of farmers to implement and manage regular insecticide-treatment of cattle themselves. However, the operations were not sustained in most areas as many farmers could not keep up with the zero grazing system proposed by the project and there was lack of technical support after the project (Meyer *et al*., 2016).

Most of the earlier control methods including ground spraying of insecticides, SAS and bush clearing are no longer extensively applied due to environmental considerations (Krafsur, 2009). The main limitation of vector control of AAT is its heavy reliance on the use of insecticides, which are liable to inducing resistance. Furthermore, in the wake of insufficient access to veterinary services in the endemic regions, farmers have been indiscriminately using drugs for treatment, which has also exacerbated the problem of drug resistance. This is consistent with the observations by Ngumbi and Silayo (2017) in Tanzania that a high level of trypanocide misuse poses a high risk of trypanosome drug resistance development. Most recently, single or multiple trypanocidal drug resistant has been reported in 21 African countries where the problem is increasing and rapidly spreading (Tsegaye *et al*., 2015).

While progress has been made on reducing economic injury of AAT, there are challenges which continue to hinder complete eradication of the disease. For instance, when compared to livestock diseases such as Foot-and-Mouth Disease, Rinderpest and Anthrax, AAT is unknown by majority of people in communities where the disease occurs (Machila *et al*. 2007). Lack of public awareness and community involvement in current approaches is an obstacle undermining AAT control programs. Namangala and Odongo (2013) posit that effective control of AAT requires dedicated efforts on community education. This makes stakeholders fully aware of the disease thus easy institution and implementation of control program.

2.3 Integrating communities in tsetse and trypanosomiasis management programs

Despite decades of control efforts targeting AAT, its spread has hardly receded and the situation in the SSA region has recently been described as “serious and deteriorating” (Meyer *et al*., 2016). An equally important aspect in the control of tsetse flies and AAT is the active community involvement. However, community participation in disease control is minimal in

many parts of SSA and this has been partly attributed to community knowledge gaps about the disease and the vectors (Mboera *et al*., 2007).

Community participation is defined as "a process in which people take part in decision making in the institutions, programs and environments that affect them" (Shackleton *et al*. 2002). Community participation is usually conceptualized as a process by which members of the communities individually or collectively assume increased responsibility for assessment of their own needs, and once these are agreed upon, identify potential solutions to problems, and plan strategies by which these solutions may be realized (Bermejoand Bekui, 1993).

Community participation in health programs has been found to be critical towards their success (Mlozi *et al*., 2006). The benefits of community participation for health programs, including increased coverage, efficiency, effectiveness, equity, sustainability and self-reliance, were first recognized and accepted by the World Health Organization (WHO) in 1991. In its 55^{th} regional committee for Africa held in 2005, the WHO approved strategies to advocate for increased awareness of the risks and consequences of human African trypanosomiasis (HAT), with emphasis on community participation at all stages of the fight against this disease. The approach can equally be extended to AAT as the two diseases are caused and spread by tsetse.

Traditionally, most tsetse control programs in Africa have been managed and carried out by central governments through tsetse control units (Rich and Perry, 2011). However, such programs have lacked sustained support. Additionally, veterinary services are also insufficient and inaccessible. The consequence is that most farmers often resort to indiscriminate self-administration of drugs without professional diagnosis and guidance, thus unknowingly and unwillingly increasing the risk of drug resistance (Geerts *et al*., 2009). Studies show that the current control techniques, especially use of traps and repellent collars hold a massive potential

in the control of tsetse and AAT (Saini *et al*., 2017). The new techniques offer possibilities for new management approaches. However, for efficiency and sustainability, tsetse control *programs* using traps and targets which have been initiated to date should involve local populations in various ways. The concept of community participation in the control of tsetse populations is not new.

Various seminal studies on community participation in AAT management suggested the need for creating local awareness about the problems of tsetse and trypanosomiasis and the function of the technology in order to reduce theft and vandalism; the provision of traps and marking targets with local communities undertaking partial or full responsibility for targeting and deploying, setting and maintaining traps (Swallow and Woudyalew, 1994; Dietvorst, 1995; Omolo *et al*.,1995; Mwangi, 1996; Barrett, 1997; Echessah *et al*., 1997).

Bouyer *et al*. (2013) suggested that local integrated pest management would be the best option in cases where AAT eradication is no longer tenable. With this approach, farmers and communities will need to conduct tsetse control in order to reduce their density enough to reduce transmission of AAT and lower the probability of resistance to trypanocides within cattle populations. Meyer *et al*. (2016) shares the same sentiments that lack of involvement of the target communities in the control of tsetse and AAT *programs* is the main limiting factor towards sustainable management of the disease.

Following the inefficiencies and drawbacks of the existing control methods, CORPs are proposed by ICIPE as key to sustainable integrated approach in the control of tsetse and AAT. However, some factors must be considered in selection and training of the CORPs. For instance, Killeen *et al*. (2006) explains that resourceful community persons often rely upon carefully choosing relatively few skilled personnel who shoulder the responsibility of implementation and

communicating to the community, so as to maximize compliance and effective coverage. Past studies on CORPs within health domain suggested that well-chosen health personnel selected from within a community are more likely to gain community confidence (Oakley, 1981; Okanurak and Sornmani, 1992) and are effective in facilitating behavior change when targeting specific outcomes (WHO, 2006). It is therefore essential for program managers and policy makers to bring the relevant communities on board before implementation. This enables collective understanding and anticipation of local political forces, cultural and social interactions, and community expectations. Additionally, inclusion of the community in design and implementation of control programs influences participation among not only recruited individuals, but also the entire community (Schneider and Lehmann, 2016). Moreover, if people do participate, it is important to understand how they interpret and value their involvement in the program over time.

2.4 Policy and institutional constraints to sustainable livestock disease management

According to Scoones (2014), trypanosomiasis slipped down the list of priorities in SSA since the peak of colonial efforts. Grant *et al*. (2015) noted that there has historically been a lack of one-health-approach working in the control of AAT compared to other diseases that affect both animals and humans. Kahn *et al*. (2011) defines *One Health* approach as the relatedness of human, animal, and environmental health and the importance of transdisciplinary efforts in the management of human and animal diseases. This approach has been recognized by the FAO, UN and WHO as a major element in disease control and prevention. Okello *et al*. (2014) however insists that there is need for policy and institutional reforms for *One Health* approach to succeed in SSA. The complex interacting factors that impact the disease show the need for cross-sector,

interdisciplinary decision making to stop rival narratives leading to competing actions (Grant *et al*., 2015).

The introduction of the Structural Adjustment Programme (SAP) in the 1980's by the International Monetary Fund (IMF) meant that animal disease control programs that had predominantly been managed by the government, were transferred to the private sector in an effort to reduce the public administration role in veterinary services management (Cheneau *et al*., 2004). Since then, control methods focused on specialized technological solutions rather than more holistic One Health approaches and this polarized conservationists and agriculturalists resulting in conflict and disagreement in policy making. In most parts of SSA, conservationists argue that tsetse, and AAT are playing an important role in protecting natural areas that would otherwise be exposed to human and livestock settlement (Ducheyne *et al*., 2009). As such, they have supported policy decisions that are reluctant in eradication of the disease (Scoones, 2014). Development economists on the other hand perceive tsetse as an obstacle to poverty alleviation in the region and they argue that it should be a top priority on the policy agenda (Scoones, 2014; Grant *et al*. 2015).

Efforts to control trypanosomiasis have varied in intensity since they became institutionalized in the colonial era. During that time, trypanosomiasis control was a priority issue and around a quarter of the colonial research budget was focused on AAT control and persistent efforts to push back the fly belts (Rodgers and Randolph, 2014). According to Grant *et al*. (2014), existing efforts in the control of AAT are derailed by low funding from national governments and lack of cross-sector partnerships. This causes frustration to those within the ministries in charge of trypanosomiasis. The veterinary officers, researchers and extension officers hold that lack of sufficient and timely funding has limited service provision to farmers whose stock have

contracted trypanosomiasis. Braks *et al*. (2014) also noted that broad institutional changes, capacity building and dissemination of information forming the evidence base on trypanosomiasis are required as well as inter-ministerial platforms to coordinate policy and action for disease control. More importantly, there is need for cross cross-sector partnerships which have the capability to improve preparedness and contingency planning, cost-sharing between sectors, increased equity in health, and increased sharing of logistics and service provision costs.

Grant *et al*. (2014) also urges the need for a paradigm shift in the way disease monitoring is currently carried out for effective control of AAT. With current dynamics, AAT monitoring should focus on a disease to whole-system surveillance, interactions between disease drivers, disease incidence at the community level, and poverty and equity impacts. This would be vital in creating a strong evidence base to aid in the control of the disease. However, this would need new organizational arrangements, expert diversity and direct involvement of the local communities affected by the disease. Bringing the interests of the local communities on board is important to gain their support and ensure that the designed control programs can be sustained after projects and funding have ended. Local support also ensures that a sufficient number of people contribute towards creating public goods (Bruton, 1994).

2.5 Review of methods for analyzing preferences

From literature, revealed preference (RP) and stated preference (SP) methods are the two main methods used respectively for valuation of non-market goods/services and newly introduced goods/services *ex-ante*. This study recognizes that the CORPs may not necessarily be a non-market good, but seek to offer a shift from status quo in the control of TandT. It is in this line that this study anchors analysis of preferences for CORPs as a non-market evaluation approach.

The RP methods are applied to study a closely related market for the good or service in question by using data from actual behavior or choices people make within markets. Hedonic pricing and travel cost methods are common examples of RP methods. However, the RP methods have two main limitations of conditioning valuation on current and previous levels of the good/service under evaluation and the impossibility of measuring non-use values (Martinsson *et al*., 2001). These limitations have shifted practical application from RP to SP methods. The SP methods assess the value of the good by using an individual's stated behavior in a hypothetical setting. The SP methods are advantageous in such a way that the researcher is able to control relationships between attributes, which permits mapping of utility functions with technologies different from existing ones, as well as being able to include existing and/or proposed choice alternatives (Hearne *et al*., 2004). The main SP approaches are conjoint analysis (CA), contingent valuation method (CVM) and CE.

The CE approach has been given more attention over CA and CVM because of its consistency with the random utility theory (RUT) in the valuation of non-market goods/services or introduction of new goods/services that seek to change the status quo (Adamowicz *et al*., 1998). This means that unlike CA and CVM, the CE method allows respondents to choose from among alternative bundle attributes rather than ranking them. The CE evolved from theory of individual choice behavior. Specifically, as noted by Louviere *et al*. (2000), the CE approach is derived from Lancaster's theory of demand, which assumes that any good/service can be decomposed into a finite set of characteristics, referred to as attributes. Individuals derive utility not from the good/service itself, but from its attributes (Lancaster, 1966). The CE is an appropriate approach for this study as it examines individual preferences for CORPs' services.

The CE method values a good or service by separately analyzing the preferences of individuals for the relevant attributes that characterize the good. This provides much information that can be applied to the preferred design of the good (Hearne *et al*., 2004). For these reasons, the last two decades have seen CE become an accepted approach to study the behavioral response of consumers, households or even organizations in different applied fields such as environment, transport, market research, health economics and econometrics (Louviere *et al*., 2000).

Within CE, respondents are asked to assess a number of options described by a set of attributes and choose that one which best matches their preferences. This is repeated as many times as choice situations are presented to the respondent. Besides its consistency with RUT, CE provides a possibility of obtaining more information from a relatively small sample size and the possibility to test for internal consistency. Additionally, it provides for implicit elicitation of WTP among the respondents (Hanley *et al*., 2001).

2.5.1 Applications of choice experiments

Since its original application in environmental economics by Adamowicz et *al*. (1994), CE application has gained popularity in other disciplines such as marketing, transportation, health economics and psychology studies. Recent literature shows extension of CE in either designing new policy or improving existing policy interventions. For instance, CE has been applied to develop policies in consumer food quality and safety preferences and improvement of existing food products (Otieno and Nyikal, 2017; Pambo *et al.*,2017 Ceschi *et al.*, 2018; Otieno and Ogutu, 2019).

Similarly, the CE approach has been applied to develop policies in natural resource management such as livestock disease management, water soil and environmental management and conservation. For instance, Otieno *et al.,* (2011) applied CE approach to analyze farmers'

preferences for disease-free zones in Kenya. Latacz-Lohmann and Breustedt (2019) applied the technique to improve the design of environmental schemes in Northern Germany while Buschmann and Röder (2019) analyzed the farmers' preferences for agri-environmental schemes in Germany. Notably, all these recent diverse applications of CE have informed policy design by breaking down the policy into various specific components. Comparably, this study contributes to literature through application of the CE approach to assess farmers' preferences for CORP attributes for integration in AAT management programs.

2.7 Conceptual framework

According to Lancaster (1966), the attributes of a good or a service inform an agents' decision to use the product. Therefore, the starting point of this framework as shown in Figure 2 is consistent with this theory that the attributes of the CORPs will inform their desirability among farmers. These attributes include both individual-specific characteristics such as age, gender, level of education and social status and program-specific attributes such as the training provider. Innovations centered around people, for instance CORPs in this context, are usually dynamic and establishing an efficient set of desirable attributes depend on social and economic characteristics of the CORPs and the existing policy and institutional factors.

The adoption theory further adds that other non-technology specific characteristics influence the agents' preference for the product being introduced. As a result, household socio-economic characteristics such as household size, education of the household head, age of the household head, land size, on-farm and off-farm income and institutional factors such as access to extension and veterinary services, social networks, access to credit and market access, have all been included in the conceptual framework. The institutional factors are usually beyond the control of

the households, thus, they have mixed effects in determining the households' preferences for integration of CORPs in ATT management programs.

An efficient integrated approach will also depend on the nature of the existing multiple AAT management methods which can be complementary, substitutes or a combination of both. Complementary control methods would favor integrated AAT management as opposed to substitutes in an event where the households are faced with multiple AAT control methods. Even though substitutability is for sustainability, it is mostly desirable and applicable when resources are limited (Traeger, 2011; Fenichel and Zhao, 2015; Baumgärtner *et al*., 2017). However, where agents are faced with multiple alternatives to choose from, the complementary nature of those alternatives is more desirable for sustainability (Pezzey and Toman, 2017). The implication is that farmers would not need to substitute one AAT control method with another but they will combine various complimentary control methods. This will increase prospects of decreasing tsetse population and AAT incidences. Consequently, this is expected to lead to reduced mortality rates, improved output, higher household incomes and improved household food security.

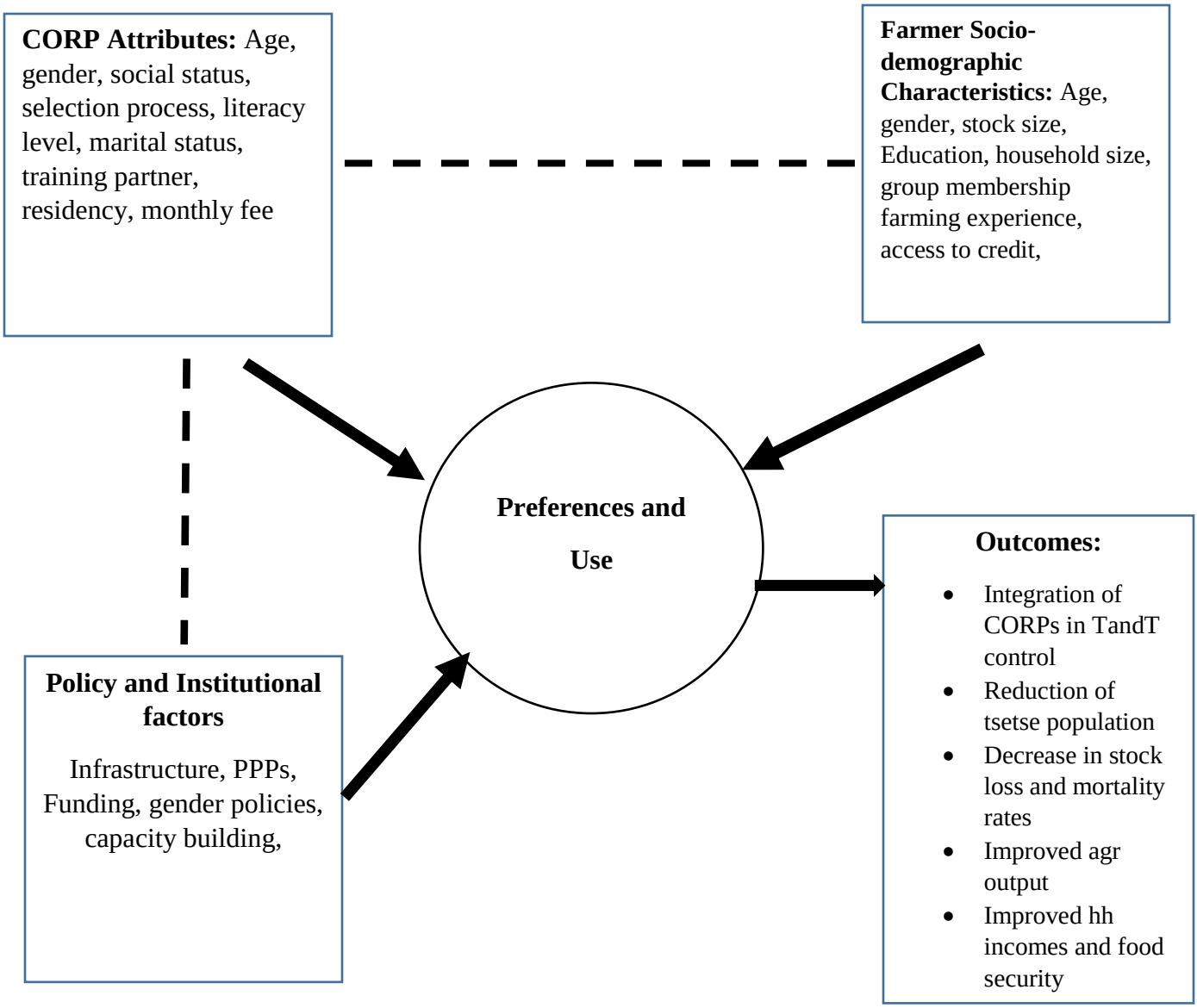

Figure 2: Conceptual Framework

Source: Author (2019)

2.8 Theoretical framework

The random utility theory (RUT) provides an analytical basis for CE data. This theory is consistent with Lancaster's economic theory of value and neoclassical economics which posit that individuals derive utility from the characteristics of a good/service rather than directly from the good/service as a whole (Lancaster 1966; Manski 1977). Therefore, the farmers' preferences for integration of CORPs in AAT management are defined over bundles of attributes and the demand for CORPs' services is a derived demand. Behind this assumption lies the recognition that attributes are objectively measurable and fully known. The inclusion of Lancaster's theory does not violate the neoclassical foundation. Instead of describing the relation between two goods, the marginal rate of substitution (MRS) describes the relation between two attributes.

The RUT therefore allows researchers to elicit preferences for complex multidimensional goods/services, from which models of preferences can be estimated. The assumption is that individual agents make choices to maximize their utility (random utility maximization hypothesis).

In the context of this study, it is hypothesized that farmers are making two choice decisions. First, livestock keeping households choose among the existing multiple AAT control methods. Second, a choice decision is made on hypothetical CORP alternatives based on the preferred attributes of the CORPs. In either case, the RUT provides that these households would choose alternatives that maximize their utility. Following this theory, the utility that an individual *n* obtains from alternative *j*, labelled U_{nj}, is expressed as a function of attributes (X):

$$U_{nj} = \beta_n X_{nj} + \varepsilon_{nj} \quad \text{.....(1)}$$

Equation 1 above shows that utility is composed of two parts: systematic or measurable component β_n that is a function of observable attributes (X_{nj}) and a random component capturing

variations in preferences in the population due to unobservable stochastic error term ε_{nj}. On this account, the RUT underpins the econometric basis of CE (McFadden, 1974).

In this theory, utility is considered unobservable to the analyst thus a random variable measured as a probability that rational individuals make choices of goods from which they obtain the highest utility in any given choice set. The randomness arises from the effects of unobserved attributes and taste variations, latent individual characteristics and measurement errors.

The RUT assumes that the individual acts rationally and chooses the alternative with the highest level of utility implying that an individual is a utility-maximizer. As the researcher cannot observe the individual's true utility function, a probabilistic utility function is used in the estimation. Assuming that a farmer can choose between two alternatives of CORPs, *i* and *j*, based on the desired attribute bundle of the CORPs, then the probability that alternative *i* is chosen is given by:

$$P_i = \text{Prob}(U_i > U_j) = \text{Prob}(V_i + \varepsilon_i > V_j + \varepsilon_j) = \text{Prob}(V_i - V_j > \varepsilon_j - \varepsilon_i) \quad \forall\, i \neq j \qquad \text{..... (2)}$$

From this, it can be seen that the higher the probability of choosing an alternative, the larger the difference in observed utility.

As stated earlier in this section, the RUT is consistent with neoclassical theory, which builds on a number of axioms that give the desired properties to the consumer's preference relation, thus they ensure that preferences can be represented by a numerical scale (utility). The axioms ensure that the bundles of different hypothetical CORP alternatives under study are ordered by the farmer's preference function and that the farmers behave rationally. It is assumed that the farmers have complete, stable and consistent preferences and that their indifference curve is continuous. If preferences are incomplete, unstable and inconsistent then they must be

constructed at the time they are elicited, indicating that the process might be driven by heuristics and affected by context (Swait and Adamowicz, 2001). The continuity axiom rules out lexicographic orderings such as dominant preferences, and ensures the concept of trade-off (MRS) which is one of the core principles of the CE. Violation of one or more of these axioms significantly influences the interpretation of the CE results.

CHAPTER THREE: CHARACTERIZATION OF ROLE OF LIVESTOCK ON LIVELIHOODS AND ANIMAL TRYPANOSOMIASIS MANAGEMENT

3.1 Abstract

Control operations for AAT and its vectors, mainly tsetse, have been ongoing for over decades in SSA. However, the disease is still endemic in approximately 68 percent of African countries. The continued threats imply that future policies in the management of the disease and its vectors require a detailed re-examination of the past and ongoing control practices and methods to identify the gaps and challenges. Further, a successful integrated community-led AAT management program is based on a clear understanding of the current AAT management methods used by the affected households. Against this background, this chapter characterized the current AAT management methods, the drivers and challenges with the previous management methods, and the role of livestock in farmers' livelihoods using 5 focus group discussions (FGDs) each comprising 10 randomly selected livestock keepers, an extension officer and one veterinary officer and household survey data from 308 livestock keeping households in Kubo south Ward, Kwale County of Kenya. Results show that cattle keeping was common in all households while sheep, goat and chicken ownership was observed in about 17 percent, 74 percent and 86 percent of the households, respectively. The main uses of livestock are draft power, milk, and meat production and for sale to generate extra household income. The contribution of livestock to household income was about 40 percent. The insights from FGDs revealed that the main drivers of change in the evolution of AAT management methods and practices were population growth, climate change, infrastructure development, technological advancement, entry of international research organizations and devolution. Currently, the main AAT management methods are the use of repellent collars, trypanocides, selective bush clearing, and traditional herbs.

Keywords: Animal trypanosomiasis, management methods, drivers of change, Kenya.

3.2 Introduction

The rising population levels in many parts of SSA have caused increased land pressure, pushing more people into tsetse-infested marginal areas (Reid *et al*., 2000). As a result, immigration has led to either elimination of tsetse habitat, hence disappearance of tsetse flies and apparent elimination of the disease or increased animal-fly contact, leading to increased risk of contracting AAT (Guerrini *et al*, 2008; Kone *et al*., 2010; Mwanakasale and Songolo, 2011). The latter has been more evident in Kenya's context. This is contrary to earlier simulation models which suggested that population growth would cause a decline of savannah and forest tsetse, with possible extinction in eastern and southern Africa (Reid *et al*, 2000).

In Kenya, tsetse populations have been confined to discrete habitats, with a high abundance in and around wildlife conservation areas such as game parks and reserves. Such conservation areas provide suitable conditions for tsetse survival and function as breeding sites. With increased human encroachment into these protected areas, there is bound to be an increased animal trypanosomiasis risk. Indeed, this is the exact situation in Kwale County which borders Shimba Hills national game reserve. Over the years, farmers in this region have suffered massive losses as a result of animal trypanosomiasis. These losses include reduced meat and milk off take, weight loss, reduced traction power of oxen, high stock mortality and overall cost of livestock management.

Subsequently, with the current insufficient veterinary services in Kenya, farmers in such endemic areas resort to presumptive and indiscriminate drug administration thus increasing the risks of drug resistance. The resulting losses coupled with shifts in land use practices, increasing population, environmental concerns with some control methods, and emerging institutional

arrangements within farming communities has prompted agro-pastoralists to adopt more resilient strategies where they not just rely on one trypanosomiasis and tsetse control method but a mix of various methods and practices which are interdependent.

Consistent with the ongoing efforts towards an integrated AAT and teste management, this chapter characterized the livestock livelihood practices, challenges in livestock production mainly focusing on AAT, the existing AAT management methods used by farmers and the challenges with these methods. A clear understanding of the existing AAT management methods and their challenges is important in designing more efficient and sustainable integrated AAT management programs.

3.3 Methodology

3.3.1 Sampling design and sample size determination

A total of 308 livestock farming households selected through a multistage sampling method were interviewed. In the first stage, Kubo south Ward in Kwale County, Kenya was purposively selected as it is ICIPE's project site on "*Up-scaling integrated control of tsetse and trypanosomiasis among agro-pastoralists in Kenya*." Besides, the region is one of the areas most affected by tsetse and AAT in Kenya with a prevalence rate of approximately 56 percent (McCord *et al*., 2012; Mbahin *et al.,*2013). In the second stage, 6 blocks (Msulwa, Kipambani, Kizibe, Mlafyeni, Pengo, and Katangini) were selected using simple random sampling from a total of 12 blocks in Kubo South Ward. In the third stage, a proportion to size method was used to identify the number of respondents from each of the 6 blocks using a list of livestock farming households which were part of the initial baseline survey by ICIPE for this project (Muriithi et al., 2018). Therefore, this method was most appropriate in selecting a representative sample from

each block. In the final step, systematic random sampling was used to select every $n^{th} = 2$ respondent.

Following, Cochran (1977), when the population is unknown, sample size can be determined as shown:

$$n_0 = \frac{z^2 p(1-p)}{e^2} \qquad (3)$$

where n_0 is the sample size to be determined, *p* is the estimated proportion of the population that would be available at the time of the survey, *e* is the acceptable margin of error for proportion being estimated and *z* is the critical value of the desired confidence interval. Setting the maximum possible proportion of *p* at 50% with a 5% margin of error and 99% confidence interval whose critical value *z* = 2.58, the sample size would be:

$$n_0 = \frac{2.58^2 \times 0.5(1-0.5)}{0.05^2} = 666 \ldots\ldots (4)$$

However, since the population from which the respondents were sampled from is known to be 600, Cochran (1977) correction formula was applied as follows:

$$n = \frac{n_0}{1+\frac{n_0}{N}} \ldots\ldots (5)$$

where n_0 is the sample size obtained in equation (4), and N is the population. The ideal sample size for this study is therefore given as:

$$n = \frac{666}{1+\frac{666}{600}} = 316 \qquad (6)$$

Equation (6) shows that the desired sample size for this study was 316. However, a sample size of 308 households was used for analysis as 8 questionnaires had incomplete and missing data during data entry, thus discarded and excluded from analysis.

3.3.2 Data collection procedure

Data was collected through FGDs and household survey. A total of 5 FGDs each comprising 10 farmers, 1 extension officer, and at least 1 veterinary officer were conducted in May 2019 in five selected villages from the study area. The use of FGDs was informed by its ability to broaden research issues and eliminate data collection bias (Milena *et al*. 2008). The FGDs provided general information on the prevalence of AAT in the area, the past and the existing management methods, the drivers and challenges with the past AAT management methods, and the farmers' perceptions and attitudes on the integration of CORPs. Further, FGDs were also necessary for validation of the CORP attributes to enter the optimal CE design. The household survey was conducted through face-to-face interviews using a structured pretested electronic questionnaire in REDCAP survey software. The electronic questionnaire was administered by adequately trained local enumerators who have a vast knowledge of the farming practices in the study area. The enumerators were trained for four days, followed by a survey pre-test to assess the enumerators' skills and abilities with the electronic questionnaire.

The questionnaire sections captured detailed information on village, household socio-economic composition, and characteristics, land tenure and characteristics, livestock production and management, AAT prevalence and severity, tsetse and AAT control methods, knowledge and perceptions with the existing control methods, challenges with the current control methods and institutional factors such as access to credit, agricultural group membership, access to market and state of infrastructure. Furthermore, the questionnaire had a CE section that contained different

CORP profiles and scenarios for capturing data on farmers' preferences for CORP's attributes and WTP for the integration of CORPs in tsetse and AAT management.

The data was analyzed in excel (for graphs) and STATA version 15. The CE data were analyzed using NLOGIT version 5 software while qualitative analysis was employed on FGDs data.

3.4 Results and discussion

3.4.1 Socio-economic profiles of the respondents

Table 1 shows the socio-economic profiles of the sample households. About 89 percent of the households are headed by men who are averagely 54 years old. These results are consistent with recent findings from the study area by Wamwenje *et al*., (2019). Markakis (2004) also observed that men are the decision-makers in livestock keeping households as they have more access and rights to economic resources compared to women. Further, the average household size is 5, which is an exact reflection of the latest population and housing census results in Kwale county (Republic of Kenya, 2019).

The majority of the household heads had primary education as the highest formal education level; average years of formal schooling was 7. According to KNBS and SID (2013), not more than 16% of Kenya's population above 50 years had attained secondary school education. Similarly, Kwale county is classified as one of the semi-arid lands which are generally characterized by low human development indices, including literacy levels (Njoka *et al*., 2016).

Land size and ownership and distance to the game reserve play a major role in determining livestock grazing patterns as revealed by the FGDs with the selected household members. Consistent with those FGD findings, the survey results showed that the average household land size was 8.5 acres. On average, the distance in walking time to the Shimba Hills game reserve was 1.5 hours. The relatively larger land sizes and longer walking distances to the game reserve

could be the reasons why there were variations in grazing patterns. Grazing in household-owned land was reported by slightly more than half (52.3 percent) of the respondents. Similarly, 52.6 percent of the households also reported that they graze their livestock in communally-owned land.

Table 1: Socioeconomic characteristics of sample households

Variable	**Mean (n = 308)**	**Std. deviation**
Average age of household head in years	54.27	13.50
Average years of formal education of household head	7.21	4.00
Household size	5.16	2.01
Average land size in acres	8.46	13.84
Average livestock size	15.55	12.52
Average household monthly income[a]	18,141.92	26,938.57
Average distance (in walking minutes) from residence to nearest livestock market	271.73	377.13
Distance (in walking minutes) from residence to the national game reserve	80.88	76.06
Average distance (in walking minutes) from residence to credit source	104.40	83.21
Average share of livestock to household income	39.04	28.41
	Percent of respondents (n = 308)	
Gender of household head (male)	88.96	
Grazing in own land (1= yes)	52.27	
Grazing in communally owned land (1= yes)	52.60	
Access to credit (1 = yes)	20.78	
Access to extension services(1= yes)	26.62	
Access to veterinary services(1= yes)	32.79	
Access to livestock training (1= yes)	36.16	
Group membership (1= yes)	21.43	

[a]1USD=103 Kenyan shillings (Ksh) at the time of the survey

Source: Survey Data (2019).

The average number of livestock per household was 16. The four types of livestock owned by households as shown in Figure 3 are cattle, sheep, goat, and chicken. Cattle ownership was reported by all households while sheep, goat and chicken ownership was recorded in about 17 percent, 74 percent and 86 percent of the households, respectively.

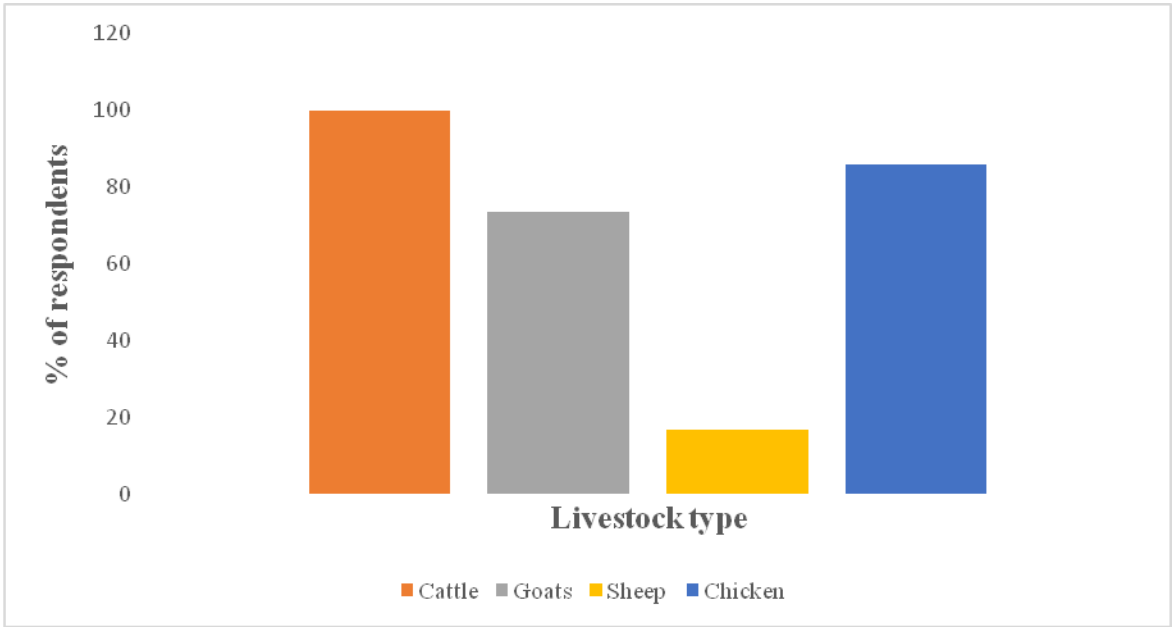

Figure 3: Livestock composition

Source: Survey Data (2019).

Less than one-third of the sample households received extension services in the last 12 months while only one-third of the households received veterinary services in the same period. However, about 37 percent of the respondents had received training on livestock management, livestock production, and livestock disease management. The main sources of training can be attributed to both government and non-governmental organizations (NGOs) such as ICIPE who have developed a strong research interest in livestock diseases in the region.

Regarding rural social networks, about 21 percent of the respondents were members of a rural agricultural development group for approximately 5 years. Out of those who belonged to an agricultural development group, about one third had a leadership position in the group. This implies that they were responsible for making key decisions in the groups. Existing literature suggests that social networks such as membership to rural development groups and personal relationships inform rural households' decision making on technology adoption and risk mitigation strategies (Barret, 2005; Bandiera and Rasul 2006; Matuschke and Qaim 2008; Nyangena, 2011). In rural settings which are usually faced with inadequate information, imperfect markets and high transaction costs, social networks through development groups facilitate flow of relevant information, timely access to vital inputs, minimizes credit access constraints, reduce transaction costs and improves farmers' bargaining power thus affecting adoption of technologies and risk mitigation strategies (Wollni *et al*., 2010; Nyangena, 2011).

3.4.2 Characterization of livestock contribution to household livelihoods

Figure 4 shows how livestock contributes to household livelihood in various ways. About 83 percent of the households mainly kept livestock, especially cattle, for draft power (own use) while approximately one-third of the households were selling the draft power services to other households. Milk production and sale of live animals were also major livestock livelihood activities among 79 percent and 71 percent of the households, respectively. About 23 percent of the households kept livestock for meat while about 15 percent used livestock as a source of farm manure. Previous studies have held that livestock and livestock products are a major source of household income and food to pastoral communities (Herrero *et al*., 2012; Tembo *et al*., 2014; Nyberg *et al*., 2015). However, despite livestock being a major form of asset and source of livelihood to the majority of the households, its mean share to average household monthly

income is only 39 percent (averagely Ksh.7,100). This can be attributed to the region's exposure to tsetse and AAT risks which limits the full potential of livestock contribution to household incomes and food security.

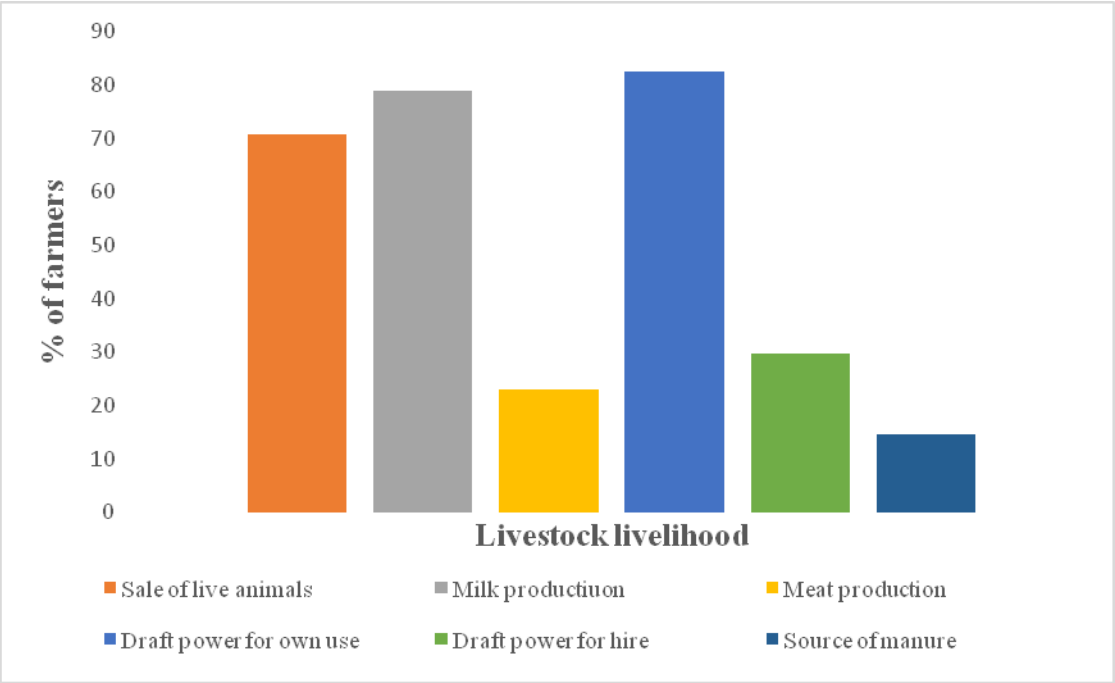

Figure 4: Contribution of livestock to household livelihoods

Source: Survey Data (2019).

3.4.2 Characterization of drivers of change in animal trypanosomiasis management methods over time

It was noted in the FGDs that there has been a series of changes in the detection and management of AAT over the last four decades. Between the years 1980 and 1989, it was reported that tsetse population was very high in the region. Few farmers owned livestock and those who owned cattle had very little and mixed information concerning tsetse and animal trypanosomiasis. This meant that farmers would realize that their stock has contracted trypanosomiasis when it is in advanced stages. The major signs and symptoms used by farmers to detect the disease were; dull

animals, continuous salivation, cattle getting sleepy most of the times and rough animal skin. Stock mortality rates were very high. The high stock mortality rates caused by trypanosomiasis were attributed to scattered human settlements in the region as most of the land was unoccupied and therefore bushy. This created perfect ecological conditions for tsetse breeding.

Further, farmers mostly relied on government veterinary services which were insufficient and the officers were inaccessible. Lack of good communication channels and the poor state of roads in the region contributed a lot to inaccessibility to veterinary services. However, farmers reported that they had their own ways of managing the disease and its vectors. Selective bush clearing and burning to reduce the tsetse population was the most dominant during this period. Besides, farmers also used smoke from burned coconut leaves and husks to keep off tsetse from their homesteads.

Additionally, it was reported that the use of traditional herbs as drugs (ethnoveterinary) was common in reducing the economic injury of animal trypanosomiasis. For instance, a liquid extracted from sweet potato vines mixed with coconut water was common. It was also noted that community cattle dips were in some way protecting the cattle from tsetse bites even though they were mainly used to control ticks and tick-borne diseases.

From 1990-1999, it was noted that there were efforts by the government to recruit and train young men and women on tsetse control and trypanosomiasis treatment. The government used this as a way to empower the community in the fight against the disease and its vector. However, this initiative was not sustained due to lack of continued support from the government. Owing to costly veterinary services during this period, farmers relied on their own knowledge in detecting the disease. For instance, FGD participants reported that poor feeding habits, fatigue, and sleepy

tendencies were the main detection techniques by farmers. However, there was a tremendous decrease in tsetse population due to increased bush clearing that was triggered by increased human settlements in the area. In the mid 1990's, there was introduction of government extension services in the area which increased farmers' awareness of tsetse and trypanosomiasis. Nevertheless, farmers still relied on ethno-veterinary (use of traditional herbs) especially, smoke from burned coconut husks to control tsetse population around their residences and grazing fields. Further, community cattle dips were still used to manage tsetse and AAT within their herds.

Major shifts in control practices and perceptions on trypanosomiasis and its main vector started happening in 2000. The entry of NGOs such as ICIPE in tsetse and AAT management efforts introduced extraction of livestock blood samples for laboratory disease diagnosis. Such organizations begun recommending drugs to farmers based on diagnosis and confirmation that the livestock had indeed infected with AAT. Besides, farmers in the FGDs repored that they were trained on how to detect and manage the disease independently. However, despite the introduction of modern disease diagnosis, farmers reported that they could still look at symptoms dullness, fatigue, difficulties in breathing, bloodstains in the animals' stool and teary eyes. Generally, it was reported that there was a reduction in the population of tsetse flies and it was easier for farmers to detect trypanosomiasis compared to earlier years. Insufficient government veterinary services were reported as the main challenge to AAT management efforts between 2000 and 2009.

Between 2010 and 2019, ICIPE begun to carry out seminars on how to detect the disease, for example using symptoms like fever. Further, with introduction of devolved governments, the control efforts by the county government of Kwale have improved access to veterinary services.

However, farmers noted that the services are still insufficient. Similarly, new technologies such as tsetse traps, repellant collars, and nets for tsetse flies have been introduced during this period. Besides, drug availability and accessibility has recently improved. As noted by Saini *et al*. (2018) the relatively low cost of drugs has increased use of trypanocides. However, overreliance on drugs has led to increased cases of drug resistance. The county government begun to sensitize farmers on TandT control as well. Farmers minimized communal grazing and opted for grazing around homesteads.

3.4.3 Characterization of current animal trypanosomiasis management methods

The AAT management methods used by farmers were trypanocides (drugs), repellent collars, selective bush clearing, traditional herbs and avoidance of areas believed to be highly infested with tsetse. As shown in Table 2, repellent collars are used by 40 percent of the households. The presence of this AAT management technology can be attributed to the efforts by ICIPE in Kwale County that seek to promote the use of modern technologies in managing the disease and its vectors. Repellent collars are believed to be affordable and effective in reducing tsetse bites in livestock by 94 percent (Bett *et al*., 2015). Saini *et al*. (2017) also found that they reduced prevalence of AAT by over 80 percent and drug (trypanocide) use by 60 percent.

Table 2: Animal trypanosomiasis management methods

AAT Management methods	**Percentage of respondents (n = 308)**
Using trypanocides (1 = yes)	92.51
Repellent collars and tsetse traps (1 = yes)	40.39
Selective bush clearing (1 = yes)	59.93
Traditional herbs (1 = yes)	51.14
Avoiding tsetse infested areas(1 = yes)	48.53

Source: Survey Data (2019).

The use of drugs (trypanocides) was found to be the main control method used by about 93 percent of the farmers. The high use of drugs can be attributed to farmers' perceived high benefits and the renewed interest by the government, private sector, and NGOs in researching and investing in drug discovery and novel control methods (Scoones, 2014; Meyer *et al*., 2016).

Selective bush clearing was a common AAT management method among 60 percent of the farmers. Most livestock keepers in the study area are probably aware of the role of the physical environment in managing tsetse and AAT. In most tsetse infested areas, selective bush clearing is mainly used to create avail more land for crop production while at the same time eliminating tsetse habitats.

Livestock keeping households were also incorporating their indigenous knowledge in AAT control efforts. This is reflected in the 51 percent, and 49 percent of the households that used traditional herbs (ethno-veterinary) and avoidance of areas perceived to be highly infested with tsetse, respectively. Through FGDs, it was found that use of traditional herbs is one of the main indigenous method used by farmers. As reported in the FGDs, wild pants are used to make traditional medicine for treating livestock. Besides, smoke from dry coconut husks is also used to keep off tsetse from human settlements. These findings corroborate those of Dharani *et al*. (2015) that pastoralists and agro-pastoralists in East Africa have engaged in a long tradition of ethno-veterinary practices involving the use of many plants to prevent and treat different livestock diseases and health conditions. Similarly, a review of past control methods by Headrick (2014) showed that pastoralists and agro-pastoralists in East Africa intentionally avoid tsetse-infested areas to minimize both human and livestock-tsetse contact, hence reducing AAT contraction risks.

CHAPTER FOUR: INTERRELATIONSHIPS IN ANIMAL TRYPANOSOMIASIS MANAGEMENT METHODS

4.1 Abstract

Integrated approaches are considered to be the best ways for sustainable management of both crop and livestock pests and diseases. However, unlike in crop production, the concept is not well established in the livestock sector in the context of livestock disease management. When developing an integrated approach, it is necessary to first understand the available technologies and methods. Secondly, understanding the interdependencies in those existing methods and factors influencing farmers' adoption behavior is important to inform a sustainable integrated policy. This chapter assessed the viability of integrating different methods in AAT control efforts by assessing the substitutability and complementarity of the multiple AAT management methods used by farmers. Data was collected from 308 livestock keeping households. A multivariate probit (MVP) model was applied to assess the interrelationships in the control methods and determinants of adoption of those control methods. Results show that AAT control methods are inter-dependent and complementary. It was also found that years of formal education, household size, household incomes, and land size had mixed effects on the household's decision to adopt multiple AAT control methods. Further, with regard to institutional factors, access to credit, group membership, access to veterinary services and type and level of agricultural training also influence adoption behavior. The results justify an increased emphasis on integrated AAT management if household socio-economic and institutional constraints are sufficiently addressed.

Keywords: Animal trypanosomiasis, integrated-management-approaches, livestock, Kenya.

4.2 Introduction

Livestock productivity remains a major concern, especially among small-scale producers in SSA. The low productivity is mainly attributed to obsolete production practices, inadequate sectoral investment, adverse effects of climate change and pests and diseases (FAO, 2012; Fitzpatrick, 2013). With regard to livestock diseases, AAT remains the most important disease owing to its negative economic effects on most livestock producers in SSA. Recent studies show that prevalence and severity rates and drug resistance are on the rise in SSA (Talakai *et al*., 2014; Tchamdja *et al*., 2016).

One of the likely reasons for high prevalence and severity rates is the lack of efficient and effective management strategies while the increasing resistance rates are as a result of indiscriminate over-reliance on trypanocides. The use of trypanocides is therefore ineffective as a stand-alone AAT control method (Clausen *et al*., 2010; Grace *et al*., 2008). As a result, farmers are now considering other approaches where they adopt various control methods, besides the use of trypanocides, to manage AAT and its vectors.

This current exploration of multiple AAT control methods and practices is consistent with the concept of integrated livestock disease management especially if the multiple management methods used by farmers are interrelated. However, unlike in crop production, integrated disease management is not well established in livestock systems. Nonetheless, integrated disease management is considered to be a potential solution towards sustainable and efficient mitigation of AAT in endemic regions (Clausen *et al*., 2010; Liebenehm *et al*., 2016).

Building on these developments, this chapter assessed the interrelationships in the various control methods used by farmers in managing AAT in Kwale County, Kenya. To ascertain the concept of an integrated approach, the hypothesis that farmers are using a mix of interdependent

control methods is tested. This is followed by the second hypothesis that household socio-economic characteristics and institutional factors all determine households' decisions to adopt the interrelated multiple control methods.

4.3 Materials and methods

4.3.1 Econometric model estimation

Persistent losses caused by AAT and increasing cases of drug resistance have prompted farmers to adopt more resilient strategies where they not only rely on one AAT control method but multiple control strategies. For instance, it is more likely that farmers who use repellent collars to prevent tsetse-cattle contact, thus minimizing chances of contracting AAT, are also treating them with trypanocides as an ex-post strategy in case they contract the disease. Additionally, it is also likely that the choice of one control method could trigger the use of other control methods.

A limitation of previous studies on trypanosomiasis control methods is that they fail to consider the interdependence of different control methods. Such studies overlook the real household decision-making scenario where they often have various alternatives at their disposal. The complementarity and substitutability of all the available options to the household when making decisions are often neglected in empirical research.

The aforementioned shortcoming, which is always the case with univariate modeling, excludes essential economic information when making interdependent and simultaneous choice decisions. Therefore, building on this argument, the univariate logit and probit models are not appropriate because they assume the independence of error terms of the different control methods, whereas a household may be using multiple control methods and one method could be influenced by the use of another. Use of univariate models would result in biased and inefficient estimates (Kassie *et al*., 2013). Therefore, MVP model which accounts for the interrelationships among the various

control methods by allowing the error terms to be freely correlated is the most appropriate (Belderbos *et al*., 2004).

Following Cappellari and Jenkins (2003), a multivariate model was estimated with five dependent variables, $y_1, \ldots, y_5$ such that:

$$Y_{ij}^* = x'_{ij}\beta_j + \varepsilon_{ij}, \quad j = 1, \ldots, m \quad \ldots \ldots (7)$$

and

$$Y_{ij} = \begin{cases} 1 \; if Y_{ij}^* > 0 \\ 0 \;\; otherwise \end{cases} \quad \ldots \ldots (8)$$

where Y_{ij} (j = 1,.., m) represent the available control methods (in our case m = 5) faced by the i^{th} household/farmer (i =1,..,n), x'_{ij} is a 1 × k vector of explanatory variables that affect a farmer's choice of the control methods (household socio-economic characteristics and institutional factors), β_j is a k × 1 vectors of unknown simulated maximum likelihood (SML) parameters to be estimated, and ε_{ij} is the unobserved error term.

Equation (8) implies that the dependent variable (control method) is binary taking the value 1 if the farmer uses the control method and 0 if not.

If the control strategies adopted by a famer are independent (i.e., adoption and use of one do not affect the decision to choose and use another control method), then specifications in equations (7) and (8) would assume a univariate probit model implying that the household's decision to adopt one AAT control strategy does not in any way affect the probability of choosing any another among the available alternatives. But, since it is hypothesized that farmers are using a combination of interdependent AAT control methods and strategies, an ideal model specification is that which assumes that the error terms are not normally distributed (as in univariate probit),

but follow a multivariate normal (MVN) distribution with mean zero and a variance-covariance matrix *V*, with values of 1 in the leading diagonals given as:

$$\begin{bmatrix} 1 & \rho_{12}\rho_{13} \cdots \rho_{1m} \\ \rho_{12} & 1 & \rho_{23} \cdots \rho_{2m} \\ \rho_{13}\rho_{23} & 1 & \cdots \rho_{3m} \\ \vdots & \vdots & \vdots & 1 & \vdots \\ \rho_{1m}\rho_{2m}\rho_{3m} & \cdots 1 \end{bmatrix} \quad \text{.....(9)}$$

The hypothesis that livestock keeping households are using multiple interrelated AAT management methods, therefore, gives equation (7) an MVP model that treatment decisions to adopt various control methods jointly. This specification allows for the estimation of several equations whose dependent variables (in this case, AAT control methods) are correlated (Greene, 2002). The non-zero off-diagonal elements in equation (9) provide for this correlation, thus allowing the joint estimation of multiple equations.

The empirical model for this objective is specified as:

$$\begin{Bmatrix} Trpanocides \\ Repellent\ collars \\ Bush\ clearing \\ Traditional\ herbs \\ Avoiding\ high\ tsetse\ areas \end{Bmatrix} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 +$$

$$\beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \varepsilon_{1\ldots5} \quad \text{.....(10)}$$

where $\varepsilon_{1\ldots5}$ are the error terms for each of the equations while the dependent variables (AAT control methods) and independent variables $X_1, \ldots X_{12}$ are specified in Table 3.

4.3.2 Description of variables

The dependent and independent variables for this objective are presented in Table 3. Following existing literature, the adoption of AAT control methods which mimics the adoption of agricultural technologies and agricultural risk mitigation strategies is modeled as a function of

household socio-economic characteristics and institutional factors (De Groote and Coulibaly, 1998; Bandiera and Rasul 2006; Marenya and Barret 2007; Pender and Gebremedhin, 2007; Kaufman *et al*., 2009).

Table 3: Description of variables in the multivariate probit model

Variables	**Description of variables**	**Expected sign**
Dependent variables		
Trypanocides	Household uses drugs/trypanocides to treat AAT (1 = Yes; 0 = No)	
Repellent collars	Household uses repellent collars ((1 = Yes; 0 = No)	
Selective bush clearing	Household applies selective bush clearing to eliminate/reduce tseste population (1 = Yes; 0 = No)	
Traditional herbs (Ethnoveterinary)	Household uses medicine made from traditional herbs to treat AAT and smoke from burnt dry plant material to kill tsetse (1 = Yes; 0 = No)	
Avoiding high tsetse infested areas	Household carefully selects grazing areas to avoid high tseste infested areas, hence AAT (1 = Yes; 0 = No)	
Independent variables		
Age	Age of the household head in years	±
Household size	Number of members of the household	±
Education	Years of formal education completed by the household head	+
Income	Total monthly household income in Kenya Shillings (Ksh)	±
Livestock income	Proportion of the household average monthly income from livestock	±
Tropical livestock units (TLUs)	Standrdized expression of total number of livestock (cattle, goats and sheep) owned by the household	+
Land size	Total land owned by the household in acres	+
Credit access	Household received credit in the last 12 months (1 = Yes; 0 = No)	±
Veterinary Services	Number of times household received veterinary services (veterinary visits) in the last 12 months	±
Training	Household received agricultural training in the last 12 months (1 = Yes; 0 = No)	+
Group	Member of the household belongs to an agricultural group (1 = Yes; 0 = No)	+
Access to drugs	The household can easily access trypanocides (1=Yes; 0=No)	±

Note: Following WISP (2010), the TLU equivalents for various livestock were considered as: cattle = 1, camels = 1, donkeys = 0.8, goats and sheep = 0.2 and poultry = 0.04.

Household socio-economic characterization as guided by Valeeva *et al*. (2011) included age of household head, household size, years of completed formal schooling of the household decision-makers, household on-farm and off-farm income and household assets mainly livestock size (number of cattle, sheep, goats, and chicken owned by the household) and land size with related dynamics such as land tenure and household's grazing patterns.

The importance of considering observable household characteristics in informing household decision making is reaffirmed by Tornimbene *et al*. (2014). For instance, a household with a higher education level of the main decision-maker may have better access to relevant information and have higher off-farm incomes, thus adopting more resilient and modern control strategies and methods in managing AAT. Similarly, household assets such as bigger land sizes mean having enough grazing space for their cattle, thus reducing tsetse bites and AAT. It could also mean having more agricultural land for production hence higher productivity and household incomes, which would be invested in more AAT control methods. However, larger unmaintained land sizes may create tsetse habitats closer to households thus resulting to increased tsetse-animal contact which will eventually imply higher animal trypanosomiasis cases. Age is also likely to have mixed effects on adoption decisions. While, in some cases, age would mean being more experienced and knowledgeable about specific control methods, it might also suggest being risk-averse and laggard with the latest trends. Therefore, the actual effect of age on the adoption of AAT control methods was assumed to be indeterminate.

Concerning institutional factors, access to trypanocides can be explained by distance to market, access to veterinary services (number of veterinary visits), access to agricultural training, group membership and access to credit are hypothesized to influence household's adoption and use of various AAT control methods. As noted by Weyori *et al*. (2017), social networks such as

membership to agricultural groups, facilitate access to crucial information necessary for making essential adoption decisions. Similarly, such groups could facilitate access to drugs and other technologies for managing AAT. This is consistent with existing literature that informal institutions, access to inputs and extension services play an essential role in economic development (Bandiera and Rasul 2006; Kaufman *et al*., 2009). Furthermore, according to recent new institution economics studies, social networks are believed to reduce transaction costs, increase bargaining power, thus increasing returns to farmers (Pender and Gebremedhin, 2007). Access to agricultural training and group membership are hypothesized to positively influence the adoption of multiple AAT control methods. Access to credit and trypanocides are hypothesized to positively influence the use of trypanocides and other innovative control methods.

4.4 Results and discussion

The Wald test; X^2 *(126) =221.98* in Table 4 for the goodness of model fit is significant at 1 percent.

Table 4: Correlation coefficients showing interrelationships of AAT management methods

	Sprays and trypanocides (ρ_1)	**Repellent collars (ρ_2)**	**Selective bush clearing (ρ_3)**	**Traditional herbs (ρ_4)**
Repellent collars (ρ_2)	0.461 (0.129) ***			
Selective bush clearing (ρ_3)	0.346 (0.120) ***	0.259 (0.116) **		
Traditional herbs (ρ_4)	0.349 (0.117) ***	0.449 (0.097) ***	0.443 (0.107) ***	
Avoiding infested areas (ρ_5)	0.375 (0.121) ***	0.273 (0.111) ***	0.380 (0.102) ***	0.480 (0.889) ***

Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0: X^2 (10) = 76.26 Prob > chi^2 = 0.000***

*Statistical levels of significance:, **5% and *** 1%. Values in parentheses are the standard errors.*

Source: Survey Data (2019).

Similarly, the likelihood ratio test X^2 (10) = 76.26 (Table 4) is significant at 1 percent, thus rejecting the null hypothesis that the various AAT control methods used by farmers are independent and further justifying the use of the MVP model. This implies that estimating each equation separately (applying univariate regressions) would have yielded biased and unreliable results. Most importantly, all the correlation coefficients between multiple AAT control methods are positive and significant. Therefore, the null hypothesis that the multiple AAT control methods are not interrelated is rejected. Further, the positive significant correlation coefficients lead to a conclusion that the methods used by farmers are complementary to each other.

Table 5 presents the MVP regression results. The age of the household head has positive and significant effect on the use of selective bush clearing. This is probably because selective bush clearing was the most dominant method in early efforts to combat the disease in SSA (Muriuki *et al*, 2005). This was also confirmed through FGDs with farmers. Therefore, older farmers are well versed with selective bush clearing and therefore more likely to integrate the method in the management of tsetse and AAT.

Household size increases the probability of using selective bush clearing but decreases chances of using traditional herbs. Household size is a proxy for labor availability. Therefore, larger households are likely to invest in labor-intensive AAT management methods such as selective bush clearing. Previous studies reveal that households with larger sizes are more likely to adopt labor intensive on-farm technologies (Marenya and Barret, 2007; Kassie *et al*., 2009and2013). Similarly, the available labor if allocated appropriately can translate to higher on-farm incomes thus reducing households' chances of relying on traditional herbs but invest in new technologies such as repellent collars and trypanocides.

Formal education has a positive significant effect on use of repellent collars and selective bush clearing. Therefore, the odds of using these two methods increase with higher years of formal education. This is probably because more educated livestock keepers are aware of the importance of managing the surrounding environment to control tsetse population and are also conversant with new technologies such as repellent collars. Studies show that formal education level influences the farmers' ability to access and process information relevant to making technology adoption decisions (Mignouna *et al*., 2011). Consequently, farmers with higher levels of formal education can rationally compare benefits between different available strategies and shift to cost-effective technologies with perceived higher benefits (Waller *et al*., 1998). In that line, households with educated heads are aware that bushes create tsetse habitats around their residents; thus, selective clearing reduces tsetse population and subsequently minimizes tsetse-animal contact. Similarly, more educated livestock keeping households are likely to be aware that bush clearing and repellent collars are a cost-effective AAT and tsetse control strategy. A study by Saini *et al* (2017) revealed that repellent collars were affordable to most farmers and it was effective in reducing tsetse bites in livestock by 94 percent.

Higher household monthly incomes reduce the use of repellent collars and traditional herbs as control methods. The negative effect on the use of traditional herbs can obviously be explained by the rationale that higher incomes enable farmers to invest in new control technologies.

Table 5: Multivariate probit regression results on determinants of choice of multiple interrelated AAT management methods

	Coefficients and standard errors for AAT management methods				
	Sprays and trypanocides	Repellent Collars	Selective bush Clearing	Traditional Herbs	Avoiding tsetse infested areas
Age of HHH	-0.174 (0.424)	-0.417 (0.366)	0.694 (0.359) **	-0.497 (0.355)	-0.485 (0.349)
Household size	0.059 (0.282)	-0.069 (0.232)	0.494 (0.243) **	-0.396 (0.233) *	0.099 (0.220)
Formal education HHH in years	0.429 (0.274)	0.392 (0.228) *	0.610 (0.229) ***	0.207 (0.218)	0.060 (0.210)
Total monthly income	-0.056 (0.125)	-0.213 (0.100) **	-0.029 (0.097)	-0.435 (0.098) ***	-0.122 (0.097)
Access to trypanocides (1 = Yes)	0.728 (0.264) ***	0.030 (0.193)	-0.274 (0.191)	-0.515 (0.189) ***	-0.185 (0.186)
Proportion of monthly income from livestock	0.015 (0.005) ***	0.004 (0.003)	0.001 (0.003)	-0.001 (0.003)	-0.001 (0.003) ***
TLUs	0.290 (0.159) *	0.268 (0.141) *	0.111 (0.136)	0.216 (0.134)	0.279 (0.134)
Land size	-0.011 (0.130)	0.380 (0.107) ***	0.266 (0.103) ***	0.276 (0.101) ***	0.337 (0.100) ***
Access to credit (1 = Yes)	-0.200 (0.309)	-0.202 (0.246)	0.412 (0.242) *	0.042 (0.240)	0.588 (0.240) ***
Group membership	0.132 (0.227)	0.295 (0.147) **	0.142 (0.161)	0.228 (0.152)	0.000 (0.145)
Veterinary visits	0.261 (0.139) *	0.031 (0.067)	-0.186 (0.069) ***	0.021 (0.065)	0.033 (0.062)
Agricultural training (1 = Yes)	0.582 (0.277) **	0.809 (0.201) ***	0.533 (0.210) ***	0.575 (0.204) ***	0.262 (0.192)
Notes					
Number of observations = 214					
Log likelihood = −545.911					
Wald $chi^2(60)$ = 144.06***					

*Statistical levels of significance:*10%, **5% and *** 1%; Values in parentheses are the standard errors; HHH-Household head*

Source:Survey Data (2019).

However, the negative effect of household monthly income on use of repellent collars can be interpreted in two ways. First, correlation results in Table 4 show that the repellent collars and traditional herbs are not substitutes but complementary methods. Economic theory provides that, if two goods are complementary, then the quantity demanded of such goods move in the same direction with respect to changes in prices and incomes. Therefore, the effect of increasing monthly incomes on both control methods is expected to be the same (reduces the probability of using both methods). Secondly, as noted by Saini *et al* (2017) repellent collars were generally affordable among most farmers; it would therefore be rational for farmers to invest in more effective technologies when their incomes increase. More effective technologies such as trypanocides are usually expensive. This school of thought is corroborated by the positive significant effect of the proportion of monthly income from livestock production on use of trypanocides. Besides, as proportion of monthly income from livestock production increases, the probability of avoiding high tsetse infested areas as an AAT management strategy increases. This is also attributed to the complementarity effect between use of trypanocides and strategic avoidance of high tsetse infested zones such as areas closer to the Shimba Hills national game reserve.

The TLUs and land size are household wealth indicators and they all have positive significant effects on use of multiple AAT control methods. Larger livestock herds increase the probability of using trypanocides and repellent collars. Households with large livestock herds are likely faced with stock management and grazing challenges and therefore at higher risks of AAT. This calls for more innovative AAT management technologies like trypanocides and repellent collars. With regard to household land size, an increase in by one unit increases the households' chances of using repellent collars, selective bush clearing, traditional herbs and avoiding areas with high

tsetse infestations. Large land sizes are likely to push tsetse habitats closer to people if not well managed. Therefore, farmers will find it necessary to adopt multiple complementary control methods to effectively mitigate against AAT.

Access to institutional support services like credit, veterinary services, and agricultural training has positive significant effect on multiple AAT control methods. For instance, farmers who receive credit do not need to worry about risks of grazing near high tsetse infested zones as they can invest in effective AAT preventive and treatment technologies and methods. Further, an increase in veterinary visits with relevant advisory services and drugs, and access to agricultural training increases the household's probability of using trypanocides and repellent collars.

Access to agricultural training also increases the households' chances of adopting and using selective bush clearing and traditional herbs. This can be attributed to the role agricultural training play in educating farmers on the importance of using more than just one AAT control method. Membership to an agricultural group increases the probability of using repellent collars among farmers. This can be attributed to the valuable social capital associated with these groups as they facilitate the sharing of information on the latest control technologies and the strengths and weaknesses of different control methods. Rural agricultural groups also enhance collective decision making which ensures improved compliance with disease management (Kassie *et al*., 2009). When using repellent collars as a tsetse and AAT management method, it is not required that every animal in the herd have a collar but only a few. Therefore, farmers who belong to an agricultural group can collectively agree to buy a few repellent collars and decide to graze their herds together.

CHAPTER FIVE: FARMERS' PREFERENCES FOR INTEGRATION OF COMMUNITY-OWNED RESOURCE PERSONS IN ANIMAL TRYPANOSOMIASIS MANAGEMENT PROGRAMS

5.1 Abstract

African animal trypanosomiasis (AAT) remains the most devastating animal disease in SSA. Over the past century, various management methods have been developed but the efforts have had little impact on the eradication of the disease. There are increasing calls for the integration of local communities to ensure sustainability of future AAT management programs. The CORPs are anticipated to facilitate the transfer of new control technologies and ensure the sustainability of donor-funded AAT control programs. However, despite this recognition, the farmers' desired attributes for CORPs before integration in AAT management programs are unknown. Consequently, information on farmers' willingness to pay (WTP) for the preferred attributes is not available. Against this backdrop, this study analyzed farmers' preferences for CORP's attributes using a choice experiment (CE) survey data from a random sample of 308 households in Kwale county, Kenya. Results show that farmers prefer younger and male CORPs who are resourceful in the community to their older and female counterparts. Further, respondents preferred CORPs whose recruitment process incorporates the community all through. Lastly, there was a high positive significant preference for CORPs trained by non-governmental organizations (NGOs) such as ICIPE compared to those trained by county government. These results provide relevant insights on the ex-ante design of community-led AAT management programs in Kenya and other trypanosomiasis-endemic regions in SSA.

Keywords: Animal trypanosomiasis, community-owned resource persons, choice experiment.

5.2 Introduction

Despite decades of control efforts targeting AAT, its spread has hardly receded and the situation in the SSA region has recently been described as 'serious and deteriorating' (Meyer *et al*., 2016). An equally important aspect in the control of tsetse flies and AAT is the active community involvement. However, community participation in disease control is minimal in many parts of SSA and this has been partly attributed to community knowledge gaps about the disease and the vectors (Mboera *et al*., 2007). Previous studies have pointed out the need to bring local communities on board to create awareness on effective management of tsetse and trypanosomiasis. Collective communal responsibility is widely viewed as the best way to ensure successful transfer of technologies targeting tsetse and trypanosomiasis (Swallow and Woudyalew, 1994; Barrett, 1997; Echessah *et al*., 1997).

Bouyer *et al*. (2013) suggested that local integrated pest management would be the best option in cases where AAT eradication is no longer tenable. With this approach, farmers and communities will need to conduct tsetse control in order to reduce their density so as to reduce transmission of AAT and lower the probability of resistance to trypanocides within cattle populations. Meyer *et al*. (2016) also affirmed that lack of involvement of the target communities in the control of tsetse and AAT programs is the main limiting factor towards sustainable management of the disease.

Building on this growing consensus on untapped potential of community participation in resource management, ICIPE and other partners have proposed community-owned resource persons (CORPs) as key to sustainable integrated approach in the management of tsetse and AAT. This approach proposes recruiting and training members from the local community (CORPs) to address the insufficient veterinary and extension services and subsequently reduce

cases of drug resistance. Further, CORPs are believed to be vital in facilitating technology transfer to farmers. However, successful integration of CORPs is dependent on various factors. For instance, Killeen *et al*. (2006) explains that resourceful community persons often rely upon carefully choosing relatively few skilled personnel who shoulder the responsibility of implementation and communicating to the community, so as to maximize compliance and effective coverage. Further, earlier studies on CORPs within health domain suggested that well-chosen health personnel selected from within a community are more likely to gain community confidence (Oakley, 1981; Okanurak and Sornmani, 1992) and are effective in facilitating behavior change when targeting specific outcomes (WHO, 2006).

It is therefore essential for program managers and policy makers to bring the relevant communities on board before implementation. This enables collective understanding and anticipation of local political forces, cultural and social interactions, and community expectations. Additionally, inclusion of the community in design and implementation of control *programs* influences participation among not only recruited individuals, but also the entire community (Schneider and Lehmann, 2016). Moreover, if people do participate, it is important to understand how they interpret and value their involvement in the program over time. However, despite the perceived potential of integrating CORPs in management of tsetse and AAT, no study has assessed the desired attributes of the CORPs by the farmers. Similarly, existing literature does not provide any information on farmers' WTP for those preferred attributes. Assessing farmers' preferences and WTP for CORP attributes is important for ex-ante design of local trypanosomiasis community-driven control programs in Kenya and the rest of SSA.

5.3 Materials and methods

5.3.1 Choice experiment design

Following Adamowicz *et al*. (1998), the CE was applied to analyze farmers' preferences and WTP for CORP's attributes. As noted by Louviere *et al*. (2000) the CE approach is a stated preference method for *ex-ante* assessment of non-market goods and services. Its consistency with the RUT allows us to evaluate the utility of a good or service as a function of its attributes. Besides, Salloum *et al*. (2017) notes that the CE approach enhances design and implementation of programs through engagement of key stakeholders. Integrating CORPs in AAT management is a new concept with scanty information in existing literature and limited applications. As a result, evaluation of farmers' desired attributes and WTP for these attributes can only be possible through a non-market approach of which CE is the most appropriate non-market stated preference method.

The CE design process for CORPS's attributes started with extensive review of literature to identify and define the attributes of interest. In the second stage, to ensure relevance and reliability, the attributes were validated through focus FGDs with a diverse group (in age, gender, education, income, and religion) of 15 randomly selected farmers and key informant interviews with livestock industry health experts. Besides attribute validation, FGDs provided general information on how tsetse and AAT constrain livestock production and contribution to livelihoods. Attribute levels for inclusion in design were also identified through FGDs as suggested by Bateman *et al*. (2002). Blamey *et al*. (2002) noted that preference should be given to those attributes that are demand-relevant, policy-relevant and measurable. An attribute is measurable if it is reasonable: to obtain a probability distribution for each alternative over the possible levels of the attribute and to assess the respondents' preferences for different possible

levels of the attribute, for example in terms of a utility function. Moreover, the attribute levels specified were in accordance with suggestions by Ryan (1999) who described three key success factors when choosing the levels for each attribute: the levels must be plausible to the respondents, must be actionable to the respondents and must be constructed so that the respondents are willing to make trade-offs between combinations of the attributes. As a result, a total of 6 voluntary attributes were selected for the CE design. These included: CORP specific attributes (age, gender and social status), program specific attributes (recruitment process and training provider) and the implementation cost (CORP monthly fee). Additionally, 4 compulsory attributes were identified. These compulsory attributes as specified in the FGDs were: CORP should be a resident within the community, must have at least secondary school education, must be a religious person, must be a farmer facing same challenges as the rest of the people he/she is going to serve.

These compulsory attributes are consistent with what is provided in literature. Residency is more often an important criterion in the selection of CORPs. As Lehmann and Sanders (2007) propose, recruiting from within the community is considered a best practice. Jaskiewicz and Deussom, (2014) emphasized that trust and acceptance by the community are the main factors to consider in the recruitment of community resource persons. This is probably the reason why the farmers insisted that the CORP should be a believer (religious person) because such persons as generally perceived as trustworthy in the society, and a farmer who is faced with the same threats and risks of trypanosomiasis just like them. Additionally, following recommendations of Jaskiewicz and Deussom (2014) the minimum level of education of the CORPs cannot be completely isolated in ex-ante design of community-driven programs. The farmers pointed out that only persons with at least secondary school education should be considered for the CORP role. The explanation is

that farmers are aware that the person holding this role will be trained by the program leaders and eventually become a trainer to the rest of the farmers. Therefore, an ideal person should know how to read, write, communicate andpossess basic agricultural knowledge and skills. The farmers unanimously stated that meeting these compulsory attributes would ensure that the program recruits and trains a CORP who is reliable, trustworthy and has the interests of the community at heart.

Table 6 shows a summary of the final optional attributes for the CE design. The final 6 attributes are recommended by Caussade *et al* (2005) as having more than 6 increases the amount of information available to respondents and could also lead to high variance in the error term. Further, the 6 attributes also prevent respondents from adopting a heuristic strategy based on partial information only to solve the decision problem (Arentze *et al*., 2003). Further, the attribute levels are limited to 2 or 3 following recommendations from Caussade *et al* (2005) that having more than 3 levels makes the CE design more complex such that respondents find difficulties in processing the scenarios.

Indeed, various studies on community health have highlighted certain characteristics that have defined the success of community health workers (CHW) who are not different from the CORPs in the control of animal trypanosomiasis as proposed in this study. Kawakatsu *et al*. (2012) noted that *age, training partners*, holding a recognized position in the community (*social status*) and a visual means of identification to the community are important attributes for the operation of CORPs. One of the criteria to select community resource persons is literacy. However, the age of the CORPs will eventually be of more influence (Kawakatsu *et al*., 2012). Older CORPs are likely to receive more approval and thus significantly enhance their performance. There is more evidence that older community workers are more respected in their communities than their

younger counterparts (Ofosu, 1983). Moreover, some communities assign responsibilities based on ascribed attributes like age compared to achieved attributes such as individual's education and training levels (Bhattacharyya *et al*., 2001).

Table 6: Description of CORP attributes used in choice experiment design

Attributes	Attribute levels
Individual CORP Attributes	
1. Age	Young (20-35); Middle age (36-49); Old (50 and above)
2. Gender	Male, Female
3. Resourceful in society	Yes, No
Program specific attributes	
4. Recruitment process incorporates the local community in selection of desired persons	Yes, No
5. Training provider	Local CBOs, International NGOs, County Government
Implementation Cost	
6. Monthly fee for CORP services (Kshs)	200, 400, 600

As noted by Haines *et al*. (2007), *selection* and *recruitment procedure* for CORPs cannot be overlooked in the integration of communities in resource management. Recruitment process specifies whether the community should be involved or not. Regardless of the scale of the program, communities should often be at the center of the recruitment process and have a say on the final selection (Lehmann and Sanders, 2007). Specifically, the locals should propose their most preferred persons from which the program managers will select the most competent. Therefore, the process is important in determining the acceptance of the services of CORPs.

The cost attribute (CORP monthly fee) permits the computation of monetary trade-off between attributes of a program and expected compensation. This implies that benefits are estimated in monetary terms and causes the CE to be consistent with welfare economics (i.e. the potential

Pareto improvement condition) (McIntosh and Ryan, 2002). Results from different studies can then be compared and on the grounds of economic efficiency used in priority setting. Following revelations from FGDs, an amount of Ksh.200 was used as the base monthly fee. This is the amount that farmers who belong to an existing tsetse and trypanosomiasis community-based organization (CBO) in Kubo south ward, pay every month in mobilizing resources to collectively manage the disease. Two more levels (Ksh.400 and 600) were established to reflect progressive efforts and farmers' level of commitment to managing AAT and its resulting threats. The uniform interval for price followed price attribute levels in Otieno *et al.* (2011) and Pambo *et al.* (2017).

The NGENE software was used for the CE design in a two-step procedure. Firstly, an experimental design (pre-test) with a preliminary sample of 40 respondents was carried out. The data from this step was analyzed in NLOGIT version 6 to obtain prior coefficients for efficient design. According to Bennett and Blamey (2001), experimental design is defined as "the way in which the alternatives' levels are set and structured into choice sets". In this stage of a CE, the hypothetical choice sets are designed including the formation and pairing of alternatives. Experimental designs can either be complete factorial or fractional factorial designs.

A complete factorial design allows estimation of the full effect on the attributes upon choices; that is, the effects of each attribute, and the effects of the combination of different attributes (Hanley *et al*. 2001). However, this design produces an impractically large number of combinations or profiles. On the other hand, fractional factorial designs are able to reduce the number of profiles with omission of some of the interactions, therefore being unreliable as well (ChoiceMetrics, 2009). As a result, an orthogonal design, which is more efficient for generating subsets in such a way that attribute level balance is satisfied. Orthogonality is satisfied when the

joint occurrence of any two levels of different attributes appears in profiles with frequencies equal to the product of their marginal frequencies (Huber and Zwerina, 1996). Orthogonality is thus satisfied when the difference in the levels of each attribute varies independently over choice sets, meaning that the levels of the attributes vary in a crisscross manner. In the second step, the prior parameters estimated from the first step were used to generate a *D-optimal* (an efficient) CE design. Following recommendations from Caussade *et al* (2005) and Blemier and Rose (2010), the final CE design had a *D-optimality (D-efficiency*) value of 87.35 percent, and *B-estimate* of 85 percent. The *B-estimate* measures the degree of utility balance in the design. A *B-estimate* value equal to or greater than the minimum threshold of 70 percent implies that any single alternative in the choice scenarios is unlikely dominant (Kessels *et al*., 2004). Furthermore, *A-efficiency* of 81.71 percent implied that the variance matrix generated reliable estimates (Kuhfeld, 2005). Overall, the final design fulfilled the optimal CE efficient design principles of orthogonality, level balance, minimal overlap and utility balance suggested by Huber and Zwerina (1996) and Caussade *et al*. (2005).

The final design had a total of 24 choice scenarios/profiles. However, 24 choice profiles are too many for a single respondent. Therefore, as suggested by ChoiceMetrics (2009), the profiles were randomly blocked into 6 sets with 4 choice scenarios/tasks. Respondents were randomly assigned to one of the 6 choice sets. Each choice task had two alternatives A and B and the opt out alternative in which all the attributes of a CORP are set at zero. An example of choice set presented to the respondents is shown in Table 7.

Table 7: Example of choice task presented to respondents

Attributes	**CORP type A**	**CORP type B**	**Neither A nor B**
Age	Young (20-35 years)	Old (≥50 years)	
Gender	Female	Male	
Societal status	Yes	No	
Recruitment process	Community not involved	Community involved	
Who should train the CORPs	County Government	NGOs	
CORP montly fee	600	200	
Which one would you choose?	☐	☐	☐

5.3.2 Econometric model estimation

The CE approach is consistent with Lancastrian theory of value (Lancaster, 1966) which states that consumers derive utility not from the good/service as a whole but from the various features/characteristics of the good or service. However, the empirical analysis of CE data rests on random utility theory (McFadden, 1974).

The Multinomial logit (MNL) is the most commonly used discrete choice model in the analysis of CE data. However, it suffers from several drawbacks despite its relative simplicity. This limits its applicability in most empirical analysis. First, is the assumption of independence of irrelevant alternatives (IIA). This assumption holds that the introduction or removal of a choice into the choice-set does not affect the ratio of the probability of choosing each of the others. The second drawback of MNL is that it assumes preference homogeneity among choices. This is rarely the case, as preferences are not observable to the researcher and they vary among respondents even in cases where their socio-demographic characteristics are identical. The MNL also violates consumer axioms of transitivity and stability of choices as it imposes independence of unobserved factors over time in repeated choices. It is unusual that unobserved variables that

affect the choice in one period would not persist into the next period, inducing dependence among choices over time (Train, 2003).

Following these limitations, random parameter logit (RPL) was used for this study as it provides the researcher with valuable information regarding the interpretation of the unobserved part of utility, and provides unbiased estimates even if unobserved heterogeneity is present in the data (McFadden and Train, 2000). The RPL also provides wider options for policy interpretation as it allows for interaction of socio-demographic characteristics with the attributes of the good/service being studied.

A decision maker faces a choice among *j* alternatives. Revelt and Train (1998) give the specification of the utility derived by person *n* from alternative *j* as follows:

$$U_{nj} = \beta_n X_{nj} + \varepsilon_{nj} \quad \text{..... (11)}$$

where X_{nj} are the observed variables (attributes) that relate to the alternative and the decision maker, β_n is a vector of coefficients of these variables for person *n* representing that person's tastes and ε_{nj} is a random term that is *iid* extreme value.

The coefficients vary over decision makers in the population with density $f(\beta_n/\theta)$. This density is a function of parameters θ that represent the mean and covariance of the βs in the population. The RPL seeks to specify the function $f(\beta_n/\theta)$ and estimate the parameter θ. The estimation of the parameter θ is done through simulation of the choice probability. The maximum log likelihood method is used to estimate θ. The log-likelihood function is specified as:

$$LL(\theta) = \sum_n Ln\, P_n(\theta) \quad \text{.....(12)}$$

First, we draw a value of β from $f(\beta_n/\theta)$ and label it β^r with the subscript $r = 1$ referring to the first draw. Secondly, the logit formula, $L_{ni}(\beta_n^r)$ is calculated with the draw got from step one. Steps 1

and 2 are repeated severally before averaging the results. The average is the simulated probability given by:

$$\hat{P}_{nj} = \frac{1}{R}\sum_{r=1}^{R} L_{nj}(\beta_n^r) \quad \text{..... (13)}$$

Where *R* is the number of draws and is unbiased estimator of $\hat{P}_{ni}$ by construction. The of $\hat{P}_{ni}$is twice differentiable in the parameter θ and variable *x* , which facilitates numerical search for the maximum likelihood function and the calculation of elasticities. Then, the simulated probabilities are inserted into the log-likelihood function to give a simulated log-likelihood (SLL) function given as:

$$SLL = \sum_{n=1}^{N}\sum_{j=1}^{J} d_{nj}\hat{P}_{nj} \quad \text{..... (14)}$$

where d_{nj} = 1 if *n* chooses *j* and zero otherwise. Thus, the maximum simulated likelihood estimator (MSLE) is the value of θ that maximizes SLL. This procedure maintains independence over decision makers of simulated probabilities that enter SLL.

The ratio of an attribute coefficient and the price coefficient represents the WTP (implicit price or part-worth). This represents the trade-offs between CORPs' attributes and cost (monthly fee) attribute, which is the marginal WTP. The Computation of WTP was as follows:

$$WTP = -1 \times \frac{\beta_j}{\beta_p} \quad \text{..... (15)}$$

where β_j is the estimated coefficient for an attribute level in the choice set and β_p is the coefficient of the monthly fee attribute. Thus, WTP represents the marginal rate of substitution (MRS) or trade-off between the other attributes and the cost attribute.

Finally, following Hanemann (1984), the overall WTP commonly known as compensating surplus (CS) measure for different CORP's-led AAT management scenarios was estimated as follows:

$$CS = \frac{-1}{\beta_P}(U_1 - U_0) \quad \text{(16)}$$

where, where U_1represents the value of indirect utility associated with attributes of the CORP scenario under consideration, while U_0 is the indirect utility of the opt-out scenario. Thus, the CS measure provides useful ex-ante information on the potential acceptability of AAT management programs that integrate CORPs.

The CE data was analyzed using NLOGIT version 6 econometric software.

5.4 Results and discussions

5.4.1 Farmers' perceptions on CORP's attributes

Farmers (respondents) were asked to indicate whether they consider CORP attributes as important aspects, besides the cost (monthly fee), if they were to use the services of a CORP. Table 8 presents the results of the responses for each attribute. All the respondents were concerned with the age of the CORP, involvement of the members of the community in recruitment and who should train the CORP. About 87 percent of the respondents were positively concerned with the gender of the CORP while 77 percent of the respondents had positive concerns with how resourceful the CORP is in the community. These findings imply that recruiting and selecting the most appropriate individual to fill the role of a CORP is one of the most essential elements that contribute to a sustainable integrated AAT management approach. This can be supported by the idea that the success of an innovation or a new product/service depends on its ability to satisfy the needs of the users (Freeman and Soete,

1997). This means that users play a vital role in determining diffusion of such innovations. Collectively, the finding that more than three quarters of the respondents perceived all the CORP attributes included in the study to be important implies that these attributes are useful means for understanding farmers' preferences and WTP for integration of CORPs in AAT management programs based on the desired attributes of the CORPs.

Table 8: Respondents' perceptions on relative importance of CORP's attributes

Attributes	**Percent of respondents (n = 308)**
Age	99.03
Gender	87.01
Resourceful	76.62
Recruitment process	100.00
Training	100.00

Source: Survey Data (2019).

5.4.2 Preferences for CORP attributes

Results of the RPL model are presented in Table 9. The adjusted *pseudo-R^2* and the *log likelihood* values are 43.98 percent and -768.03, respectively. These are an improvement from the MNL *pseudo-R^2* and the log likelihood values of 11.22 percent and -892.57 respectively. This implies that the RPL model has a good explanatory power of how much variation the model accounts in the CE data. Therefore, subsequent discussions are only based on the RPL results. Dommenich and McFadden (1975) noted that adjusted *pseudo-R^2* value of above 20 percent provides a good explanatory power for discrete choice models.

Table 9: Random parameter logit estimates for CORP attributes

Variable	Coefficient	Standard Error	*p*-Value
Young (20-35 years)	4.376	0.631	0.000***
Old (≥50 years)	3.100	0.616	0.000***
Male	0.355	0.117	0.002***
Resourceful in community	1.033	0.134	0.000***
Recruitment involves community	1.350	0.157	0.000***
Trained by NGOs	3.467	2.005	0.084*
Trained by county government	0.574	0.146	0.000***
Monthly fee	-0.001	0.000	0.006***
Derived standard deviations of parameter distributions			
NsYOUNG	1.198	0.377	0.002***
NsOLD	0.610	0.547	0.264
NsMALE	1.002	0.197	0.000***
NsSOSTAT	0.453	0.283	0.110
NsCOMIN	1.164	0.207	0.000***
NsNGOS	0.993	2.702	0.632
NsCG	0.679	0.305	0.026**
Log Likelihood	-768.03		
Adjusted *Pseudo-*R^2	43.98		
n (respondents)	308		
n (choices)	1248		

Notes: starting MNL *Pseudo-*R^2 =11.22; *log likelihood* = -892.57
Statistical significance levels *10%, **5%, ***1%.
Source: Survey Data (2019).

Farmers have a higher preference for young CORPs (20-35 years) than older COPRs (50 years and above). Similarly, they have a positive significant preference for male CORPs. The higher preference for young male COPRs is consistent with the deliberations from the FGDs that, younger male CORPs have necessary networks and are more energetic, thus suitable for the intended role of the CORPs. The farmers believe that since CORPs will be required to be available all times, required to walk longer distances reaching out to farmers and most importantly, a person who has at least secondary school education, it would be more reasonable hiring young persons for the job. Feld (1981) observed that structural constraints decrease personal networks in older people. Therefore, older people are less preferred for community transformation roles as they lose their ability to reciprocate instrumental support, due to

increased functional limitations, cognitive impairment, or chronic conditions (Ikkink and Van Tilburg, 1999). Further, they noted that hiring young male persons would be more sustainable than their female counterparts as the young female persons will at some point be married elsewhere and move away from their villages/communities of origin.

The positive significant preference for male CORPs is well consistent with Eagly's (1987) social role theory which posits that widely shared gender stereotypes develop from the gender division of labor that characterizes a society. This implies that stereotypes about social groups are derived from viewing people in certain social roles. As a result, there are always gender differences in occupational roles. In an African context, just like this study site, women are generally viewed as homemakers while employment opportunities are believed to belong to men. Therefore, as suggested by Kite (1996), men are viewed to be more of agents of change in society compared to women.

Respondents also had a positive preference for a CORP who is resourceful in the community and whose recruitment process involved consultations with the community. Further probing of this revealed that farmers believe CORPs who have influence in the community are likely to be readily accepted and trusted. Such CORPs would be the perfect agents of change in addressing the weak links in the current extension services and agricultural training programs that seek to address the AAT management. Additionally, involving the community in the recruitment of the CORPs determines their acceptability and farmers' willingness to work with them. Through FGDs, farmers pointed out that an ideal CORP must: have at least have secondary school education, be a farmer, be a resident from the community and be a believer. Therefore, the only way to recruit a person with all these compulsory attributes would be through actual involvement of the community in the selection process. The positive significant preference for a CORP whose

recruitment involves the community is supported by Lehmann and Sanders (2007) who argue that the recruitment of community workers should always center around full involvement of the community.

The higher positive significant coefficient on CORPs trained by NGOs compared to county government implies that farmers in this study have a higher positive preference for CORPs trained by NGOs such as ICIPE. This is probably because several NGOs, especially ICIPE, have been at the forefront in helping farmers on better ways to manage tsetse and AAT in the area. For instance, ICIPE has carried out several tsetse and AAT management and research projects in Kubo South since mid-2000s including sensitization of farmers on efficient AAT management practices, providing farmers with new management technologies and offering veterinary services. As a result, farmers have developed trust and confidence in ICIPE and other partners (mostly NGOs) compared to national and county governments. Generally, government agents are associated with inefficiency and unreliability in service provision.

The attribute coefficients for young, male, community involvement and county government have highly significant derived standard deviations. This shows that livestock keepers have heterogeneous preferences for at least one level of each of the CORP attributes. The implication is that the preferences for these attributes are influenced by other unobservable factors. The coefficient estimate on price (monthly fee) attribute is significant and with the expected negative sign. This enables the computation of marginal WTP (part worth) estimates which represent the monetary values that respondents attach to the various CORP attributes. The WTP is the ratio of an attribute coefficient estimate and the monthly fee coefficient estimate. Table 10 presents the marginal WTP estimates for CORP attributes. These results reveal that farmers have heterogeneous preferences for CORP attributes.

Table 10: Marginal WTP estimates for CORP attributes (Kshs)

Variable	**WTP (at 95% CI)**	***p*-Value**
Young (20-35 years)	5,739.54 (4,129.80-7,386.21)	0.007***
Old (≥50 years)	4,061.64 (2,489.43-5,668.58)	0.012**
Male	465.01 (165.70-768.38)	0.029**
Resourecful in community	1,355.66 (1,014.50-2,180.03)	0.005***
Recruitment involves community	1,774.22 (1,371.32-2,180.03)	0.004***
Trained by NGOs	4554.11 (-609.46 to 9,732.46)	0.130
Trained by county government	755.24 (377.83-1131.42)	0.009***

Notes: 1USD = Kshs 100 at the time of survey. CI = confidence interval
Source: Survey Data (2019).

Respondents were willing to pay higher amounts (Kshs 4,130 to 7,386) for younger CORPs compared to any other CORP attribute. This shows that younger CORPs are more valuable and therefore more preferred by farmers. Nevertheless, farmers are willing to pay Kshs 2,489 to 5,669 for CORPs aged 50 years and above; Kshs 166 to 768 for male CORPs; Kshs 1,014 to 2,180 for CORPs who are resourceful in the community; Kshs 1,371 to 2,180 for CORPs whose recruitment process involved the community members and Kshs 378 to 1,131 for CORPs trained by the county government.

Contrary to a *priori* expectation, farmers were significantly willing to pay for CORPs trained by the county government compared to those trained by NGOs despite having a higher preference for the latter than the former. This can be attributed to the fact that these farmers are used to receiving free tsetse and AAT management services ICIPE as opposed to county governments.

Besides, most of the government veterinary services come at a fee. Additionally, the farmers WTP for CORPs trained by county government as compared to those trained by NGOs could also be attributed to their concerns with sustainability of the programs. Programs managed by the County government are more likely to be sustainable as NGO-managed AAT control programs usually end with the project closure.

Interestingly, all the WTP values for the CORP attributes are below the average household's monthly income from livestock of Ksh. 7,100 (presented in table 1). These WTP values range from 3 percent to 32 percent of the average monthly incomes implying that farmers can realistically pay per month without starving or borrowing.

5.4.3 Estimation of compensating surplus for CORP scenarios

For possible implementation of a policy that seeks to integrate CORPs in animal trypanosomiasis management programs, combination of different scenarios was essential. In order to illustrate how farmers with different preferences might respond to different CORP's attribute combinations, CS estimates were derived using equation 16 for three possible policy scenarios (Table 11). Scenario 1 was constructed to reflect the segment of people in Kenya's coastal region who advocate for residency as the main driving force for integration of CORPs. The scenario has three attribute combinations namely resourceful in community, community involvement in recruitment process and partnering with local CBOs as the training partners. In the second scenario, emphasis is on policy intervention that considers a segment of population that are concerned with issues of youth empowerment, especially men. The combination of CORP attributes in this scenario are youth, male, community involvement and partnering with county government. The last scenario has two attribute levels namely community involvement in recruitment of CORPs and county government as the training partner.

Table 11: Attribute levels and compensating surplus for CORP-led AAT management policy scenarios

Scenario	Attributes							Compensating Surplus (Ksh)
	Young	Old	Male	Leader society	Community involved	County government	Local CBOs	
1				✓	✓		✓	3129.89 *** (1088.75)
2	✓		✓		✓	✓		8734.01 *** (3037.91)
3					✓	✓		2529.46 *** (869.34)

Notes: ✓ indicates presence of an attribute at the non-zero level; *** CS estimates a statistically significant at 1% level; Corresponding standard errors are shown in parentheses. Source: Survey Data (2019).

The CS estimates for all the three scenarios are positive and significant at 1 percent, implying that farmers prefer a change from status quo to integration of CORPs in current AAT management programs. Scenario 2 has the highest CS of Kshs.8734 which represents 48 percent of the farmers average monthly income. This is approximately 3.5 times that of scenario 3, whose CS is Kshs 2529, approximately 14 percent of the average monthly income. The CS for scenario 1 is Kshs. 3130 which is approximately 17 percent of the average farmer's monthly income. The high CS in scenario 2 is consistent with the actual concerns of people in the coastal region of Kenya. In the presence of increasing cases of youth involvement in petty crime and drug abuse in the region, the residents are likely to welcome any policy that seeks to address youth empowerment and employment. As such, this policy scenario offers that option. Notably, community involvement in recruitment of the CORPs cuts across all the scenarios. This calls for design of AAT management policies through a bottom-up approach to ensure acceptability and sustainability. It is worth noting that all the CS values are less than half of the farmers average monthly incomes. This implies that there is a higher possibility of implementing a CORP-driven integrated AAT management policy without burdening the farmers. However, the values should

be taken with some caution as a more conclusive policy will be informed by having information on household's monthly expenditures on AAT drugs, cost of veterinary services, and other expenses.

CHAPTER SIX: GENERAL SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 General Summary

This study characterized the past and the current AAT management methods and assessed the interrelationships in the current management methods. Further, farmers' preferences and WTP for CORP attributes for integration in AAT management programs in Kenya was estimated. Results from the first objective showed that about 83 percent of the households were using livestock (cattle) for draft power either for own use or for hire. A further 79 percent and 71 percent of the households were using livestock for milk production and for sale to generate extra household income while only 23 percent of households used livestock as a source of meat. Despite the tremendous role of livestock to household incomes and food security, AAT was reported to be a major constraint. Findings from FGDs revealed that there have been remarkable changes in AAT management methods for the last four decades.

The main drivers of change in the evolution of the AAT management methods were population growth, climate change, infrastructural development, technological advancement, entry of international research organizations and devolved system of governance. With regard to the current AAT management methods, results showed that trypanocides (drugs), repellent collars, selective bush clearing, traditional herbs and avoidance of areas believed to be highly infested with tsetse were the main management methods. Trypanocides (drug) usage was common among about 93 percent of the households followed by selective bush clearing (60 percent). Use of traditional herbs, repellent collars and avoidance of high tsetse populated zones was observed in 51 percent, 40 percent and 48 percent of households, respectively.

Results from the second objective revealed that livestock keeping households were currently using multiple AAT management methods (trypanocides, repellent collars, selective bush clearing, traditional herbs and avoidance of areas believed to be highly infested with tsetse) that were complementary, hence interrelated. Further, the household socio-economic characteristics and institutional factors had varied effects on adoption of the multiple interrelated AAT management methods.

The RPL results from the third objective showed that farmers had a positive significant preference for the CORP attributes. This suggests that collectively, the attributes used in the CE design fully captured farmers' preference range for CORPs. Additionally, the WTP values were positive and statistically significant. The implication of positive WTP and CS estimates is that CORP-led integrated AAT management programs that accommodates these attributes would increase the acceptance of such programs.

6.2 Conclusions

African animal Trypanosomiasis is a significant constraint to livestock production in most parts of SSA. Therefore, finding a sustainable solution to this problem is of particular interest to policymakers. An integrated approach could be the most reliable course of action. However, unlike in crop production, where the concept of integrated disease management has picked up the pace, it is still new in livestock pest and disease management. This study provides a requisite stepping stone for making relevant policies on an integrated approach to managing livestock diseases, particularly AAT. As a necessary requirement towards an integrated approach, the study reveals that livestock keeping households are using multiple AAT management methods that are inter-dependent. Most importantly, these methods complement each other. A key conclusion from this complementarity is that livestock keeping households do not have to give

up one AAT control method in favor of another. Instead, the effectiveness and efficiency of one control method are enhanced by the adoption of other methods. This calls upon policymakers to promote the adoption of more than one AAT control method simultaneously.

6.3 Recommendations

The simultaneous adoption of multiple AAT control strategies is dependent on certain household socioeconomic and institutional factors. Effectively managing these factors would boost the chances of finding a sustainable solution to AAT. For instance, the significant effects of education, access to veterinary services and agricultural training suggest the need to educate and sensitize farmers more on the use of more efficient and cost-effective methods. This calls for policy interventions that focus the training of veterinary extension officers on AAT management.

Social networks are a more reliable option in the presence of government inefficiencies in the allocation of resources, for instance, inefficient veterinary and extension services. This implies that rural agricultural groups should be encouraged and supported through training in group management and leadership. However, rural institutions and networks cannot stand alone in addressing cases of market failure and missing markets. Necessary inputs and services such as drugs, repellent collars, tsetse traps, veterinary and extension services should be brought closer to the farming communities. This includes developing infrastructure such as cattle dips and local roads to reduce the time taken to access essential services.

In the presence of inefficient government extension services and unsustainable donor-funded programs, CORPs are integral to finding a sustainable solution. The findings from this study provide key insights for bottom-up design of integrated AAT management programs. Firstly, policymakers should recruit relatively younger CORPs. Secondly, community involvement in the recruitment of the CORPs would enhance their acceptability. Lastly, the county government

should partner with NGOs such as ICIPE when training the recruited CORPs on AAT management and eradication.

6.4 Contributions to knowledge and suggestions for further research

The contributions of this study on interrelationships in existing AAT management methods are twofold. First, it reveals that livestock keeping households are using a bundle of AAT control strategies that are interdependent. Previous studies analyzed adoption of individual isolated methods, thus ignoring the ideal household decision-making scenario when faced with alternatives that are complementary or substitutes. Secondly, it demonstrates the effect of household socio-economic characteristics and institutional factors on the households' decision to adopt these AAT management methods.

The study also applied CE method to elicit farmers' preferences for CORP attributes. It thus contributes to the existing body of knowledge in various ways. First, the information on farmers' preferences provides policy insights on the development of community-led livestock resource management in Kenya and the rest of the developing world. Despite the existing efforts by the government and development partners to manage and mitigate against AAT, little efforts are made to integrate the local communities in AAT management and mitigation programs. Therefore, the estimated WTP values for CORP attributes offer important policy insights on an *ex-ante* design of community-led integrated management of AAT program. Finally, the application of CE contributes to the thin body of literature, owing to the fact that empirical applications of this method in a developing country context are still limited.

The current study analyzed correlation in existing AAT management method and the effect of household socio-economic and institutional factors on the choice of the multiple AAT management methods. However, it is more likely that adoption of these interrelated AAT

management strategies and practices could be influenced by other factors such as prevalence rates, vulnerability to climate shocks, household food security status, crop productivity, ownership of communication devices like mobile phones, and participation in agricultural markets. Future studies should assess the effects of these factors on inter-relationships in the AAT control methods and their implications on the households' simultaneous adoption of the control methods.

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APPENDICES

Appendix 1: Checklist Questions for Focus Group Discussions (FGDs)

1 Livestock Farming

a) what type of livestock are kept in this area?

b) What type of livestock farming is practiced in this area? beef/dairy; local/improved breed; zero grazing/ free range

c) What are the different uses of cattle in this area? farming for the household; commercial/ hire

d) What is the economic importance of cattle farming in this area? major activities generated from cattle farming activities; draft power, milk, meat, manure

e) What proportion of households in this village keep cattle for commercial purposes?

f) On average, how many cattle does each of those household own? cow? oxen?

g) Where do you graze your animals?

2 Livestock Constraints

a) What are the main livestock production constraints in your villages

b)What are the most common livestock pests in this area? (List them starting with most important)

c) What are the major livestock diseases in this area? (List them starting with most important)

c) Is trypanosomiasis among the major farming challenges in this area?

d) How has it affected your production, stock numbers, incomes, and stock management?

i. On average, how many cattle die in a year due to trypanosomiasis disease complications? (mobility)

ii. What percent of work (draft power) is lost when animals fall sick with trypanosomiasis disease? (mobility)

e) Name the most common **trypanosomiasis management strategies/methods** used in this area, starting with the most important?

d) Have these methods been successful?

f) What are the main challenges with the methods you have been using?

g) In what ways can these methods be improved?

3 Community Owned Resource Persons (CORPs)

a) Are you aware of CORPs in this area?

b) Have you accessed any services from a CORP?

c) What proportion (or number) of livestock farmers/ households in your villages are using their services?

d) What proportion of people in this village have been able to carry out the following after introduction of CORPs?

i. To identify tsetse and tsetse bite
ii. Setting and locating traps
iii. Using repellent collars
iv. Information on which drugs to buy and where to buy them
v. How to get the exact quantities of drugs and administering the drug
vi. Information on how and where to access veterinary services
vii. Any other

e) Has the introduction of CORPs helped in any of the following ways in your villages?

i. Reduced stock deaths
ii. Reduced mortality rates
iii. Reduced rates of stock abortions
iv. Increased knowledge of drug administration
v. Information on the correct drugs to buy
vi. Faster and easy access to drugs
vii. Faster diagnosis of tsetse and trypanosomiasis
viii. Increased knowledge on how and where to set tsetse traps
ix. Ease on the use of repellents
x. Any other

f) what percent of your animals that felt sick with trypanosomiasis disease **BEFORE** and **AFTER** the introduction of CORPs in this village (in a year)? (prevalence rate), use table below

Livestock type	Prevalence BEFORE tsetse collars (%)	Prevalence AFTER tsetse collars (%)
Cow		
Oxen		
Calve		
Heifer		
Bull		
Goat		
Sheep		

g) What percent of your livestock die due to **Tsetse pest/** trypanosomiasis disease **BEFORE** and **AFTER** introduction (in a year) (mortality rate)?

Livestock type	Mortality BEFORE tsetse collars (%)	Mortality AFTER tsetse collars (%)
Cow		
Oxen		
Calves		
Heifer		
Bull		
Goat		
Sheep		

h) What are the benefits of using CORP services in tsetse and trypanosomiasis control strategies? calving interval (per year), lactation length (months), cost of production/prices? market participation (e.g. surplus maize for sale)?

Parameters/ benefits	*BEFORE CORPs*	*AFTER CORPs*
calving interval (per year),		
Abortion rate (animal/per year)		
Milk production per cow per day (liters)		
Grazing period (hours/day)		
Number of bulls owned by a household		
Number of cows owned by a household		
Selling price of an oxen (ksh)		
Number of times an animal is treated (in a month)		
Treatment expenditure (Ksh)/ pesticide use (ksh/month) or annually		
Price of ox (Ksh)		
Land under crop production/ cultivated (acres)		
Land under **MAIZE** production (acres)		
Land ploughed by hand (acres)		
Land ploughed by oxen (acres)		
Maize yield (kgs/acre)		
Other benefits		

h) What are the challenges with the earlier mentioned CORP services? (availability/accessibility, few CORPs, insufficient information, CORPs not fully equipped with the necessary skills, any other)

4 CORP Attributes

a) Do you look at specific attributes in a CORP before you use their services?

b) If yes to (a) list them

c) Suppose new CORPs were to be introduced in your area, which attributes would you them to have?

d) Among the attributes you have listed, which one do you think should be compulsory and which ones should be optional?

e) Suppose new CORPs were to be recruited and trained, would the following attributes be relevant?

i. Age
ii. Level of education
iii. Residency
iv. Training partner
v. Recognized community position (social status)
vi. Recruitment process
vii. Gender
viii. Marital Status
ix. Service coverage
x. Any other

f) Among the attributes above, which ones are compulsory?

g) Would you be willing to pay any amount for the services of CORP who has all your preferred attributes?

h) Do the following attributes affect your preference for a CORP?

Attribute	**Attribute Levels**
Individual CORP Xtics	
7. Age	20-35, 36-49, 50 and above
8. Gender	Male, Female
9. Social Status	Well recognized in community, no any social status
Program Xtics	

10. Recruitment process	Community involved, Community not involved
11. Training partner	Local CBOs, International NGOs, County Government
Implementation	
12. Monthly fee for CORP services	

Choice Experiment Pre-test

i) Now I will show you various types of crop insurance that can be made by combining these features. Kindly compare the various types of crop insurance schemes and indicate which one you prefer. Each member of the group given six choice situations to consider and make choices individually.

j) What were the experiences with the choice tasks? Were the choices easy or difficult to make?

h) While you were making choices, were you comparing all the features or are there specific features that you were looking for? Are there features that you ignored?

5 Policy and Institutional Issues

a) Are there any policy and/or institutional factors you think should be considered in the integrated Trypanosomiasis control approach?

b) How would you respond to the following policy and institutional factors?

Factor	Agree	Disagree	Not sure
Financial support for CORPs			
Training (content and frequency)			
State of roads			
Communication networks			
Involvement of local community			

in recruitment of CORPs

Land tenure

Land size

Land use practices

One Health approach

Coordination and monitoring

Environmental concerns in control practices

Appendix 2: Household survey questionnaire

QUESTIONNAIRE MODULES FOR INTEGRATION OF COMMUNITY OWNED RESOURCE PERSONS (CORPs) IN TSETSE AND TRYPANOSOMIASIS MANAGEMENT STUDY

(Note to supervisors and enumerators: only the head or spouse should attend the interview)

Introductory statement:

"Dear Sir/Madam, I am a student at the University of Nairobi and I work for the International Center for Insect Physiology and Ecology (ICIPE). We are conducting a survey to study the farmers' desired attributes and challenges for integrating community owned resource persons (CORPs) in tsetse and trypanosomiasis management project in your village. Your response to these questions would remain anonymous. Taking part in this study is voluntary. If you choose not to take part, you have the right not to participate and there will be no consequences. Thank you for your kind co-operation

MODULE 1. HOUSEHOLD AND VILLAGE IDENTIFICATION

1.1 Household Identification	Code		1.2 Interview details	Code
1. County			15. Date of interview (dd/mm/yyyy):	/ / 2019
2.Sub-County			16. Time started (24 HR)	
3. Ward			17. Name of enumerator	
4. Location			18. Name of supervisor:	
5. Sub-Location:			19. Name of data entry clerk (NOT NECESSARY IF WE USE TABLETS	
6. Village:				
7. Name of household head (three names):				
9. Name of the respondent (three names):			GPS reading of homestead	

10. Sex of respondent 1=Male		20. Way point number	
11. Name of respondent's spouse		21. Latitude (North)	
12. Ethnic group			
13. Cell phone number of household head		22. Longitude (East)	
14.Cell phone number of the spouse:		23. Altitude (meter above sea level)	

2.1 HOUSEHOLD COMPOSITION AND CHARACTERISTICS (Household members-persons who live together and eat together from the same pot (share food), including hired labourers, students and spouse living and working in another location but excluding visitors)

ID CODE	Name of household member [Start with respondent]	Sex 1=Male 0=Female	Relationship to the household head CODE 1	Age (years)	Marital status? CODE 2	Education (years of formal schooling: primary and above)	Primary occupation CODE 3
B1	B2	B3	B4	B5	B6	B7	B8
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

CODE 1		CODE 2	CODE 3	
1.Household head	6.Grandson/granddaughter	1.Married living with spouse	1.Farming (crop+ livestock)	5.Casual labouer off-farm
2.Spouse	7.Other relative	2.Married living without spouse	2.Salaried employment	6.School/college child
3.Son/daughter			3.Self-employed off-	7.Non-school child

4.Parent 5.Son/daughter-in-law	8.Hired worker 9.Other, specify……	3.Divorced/separated 4.Widow/widower 5.Never married	farm 4.Casual labourer on-farm	8.Other, specify……..

2.2 INFRASTRUCTURE (all distances in walking kilometers)

Distance to the village market from residence…….

Distance to nearest agrovet from residence…….....

Distance to the nearest cattle dip residence …….....

Distance to the nearest main livestock market from residence……

Distance to the nearest main crop product market from residence…….

Distance to the nearest government veterinary office from residence ……

Distance to the nearest credit source from residence ……...

Distance to the nearest human health center from residence …….

Distance to main water source for human drinking from residence ……

Distance to a big water body where animals are drinking (lake, river, ocean etc)……..

Distance to the national park from residence……

MODULE 3: LIVESTOCK PRODUCTIONAND TRYPANOSOMIASIS CHALLENGES

3.1 Please provide the livestock types you own now

No	Animal type	Does the household own […] 0=No; 1=Yes	Total owned by household	Total owned by Head	Total owned by Spouse	Total owned jointly (head+ spouse)
C1	C2	C3	C4a	C4b	C4c	C4d
1	Cattle					
2	Sheep					
3	Goats					
4	Pigs					
5	Donkeys					
6	Horses					
7	Mules					
8	Chicken					
9	Ducks					
10	Turkeys					
11	Rabbits					
12	Other (specify)					

What is the main purpose for keeping cattle [C5] (*start with the most important* [_____] [____] [_____] [_____](codes A)

CODE A		
1 = Draft power for own use	3 = Milk production	5. Sale
2 = Draft power for hire	4 = Meat production	6. others (specify)

What proportion of your total annual income comes from livestock farming? [C6] [_____%]

What percentage of your total annual income comes from crop farming? [C7] [_____%]

KNOWLEGDE OF TSETSE and TRYPANOSOMIASIS, MANAGEMENT, CONTROL AND CHALLENGES.

Is Tsetse and Trypanosomiasis a major challenge in your livestock? [C8] [_____] 1=YES; 0=NO

If YES, how severe do you believe Trypanosomiasis is currently in your livestock (use table below)?

		Prevalence	Mortality
No	Livestock type	Number that fell sick within the last 12 months	Number of animals that died among the ones that fell sick within the last 12 months
C9	C10	C11	C12
1	Indigenous cows		
2	Cross bred/exotic cow		
3	Oxen		
4	Bulls		
5	Heifers		
6	Calves		
7	Sheep		
8	Goats		
9	Pig		
10	Donkeys		

11	Horse		
12	Mule		

How do you detect Tsetse and Trypanosomias in your cattle? [C13] (*use codes below)*[___] [___] [___] [___]

Abortion Emaciation	Fever Death	Low milk production Diarrhoea	Starring coat Recumbency	Other (specify)

How are you currently managing /controllingTstetse/Trypanosomias ?

Current management/control methods	Does the hh use the method 0=No, 1=Yes	Who in the household decides which management method to use? (Code B)	Rank the three main methods (Yes in C20) you use in order of importance (Code A)		
C14	C15	C16	C17a	C17b	C17c
Spraying/dipping sick animals					
Delaying time of taking animals to graze					
Using repellent colars					
Clearing bushes					
Using Tsetse traps					
Fire/smoking (burning cow dung traditional herbs					
Injecting with trypanocides (drugs)					
Avoiding tsetse infested areas					

Grazing near animals with repellent collars					
10. Grazing far from other animals					
11. Smearing animal skin with ash or other ointments					
12. Other specify					

Code A			CODE B
Spraying/dippingsick animals Delaying time of taking cattle to graze Using repellentcollar Clearing bushes	Using tsetse traps Fire/smoking(burningdry cow dung or some traditional leaves) Injecting animals with trypanocides (drugs) Avoiding tsetse infested areas	Grazing near animals with repellent collars. Grazing far from other animals Smearing animal skin with ash or other ointments Other specify	1=Household head 2=Spouse 3. Household head and spouse jointly 4. Other male member of the family 5. Other female member of the family 6. Male worker 7.Female worker 8.Other (specifiy)

3.5.5 What are the main challenges and constraints with the current management and/control methods?[C18](*List THREE main)*[__] [__] [__] (Codes A)

Code A

1. High cost of drugs	7. Environmental concerns from spraying and bush burning
2. Poor access to drugs (Long distance to agrovets)	8. Human health risks with spraying methods
3. Few veterinary and extension officers	9. Challenges with drug dose calculation
4. High cost of repellent collars	10. Proximity to national park
5. Inaccessibility to tsetse traps	11. Other specify
6. Lack of skills on how to use traps and collars	

Have you been visited by an extension officer in the last 12 months?[C19][_____] 0=No, 1=Yes

Have you been visited by a veterinary officer in the last 12 months?[C20][_____] 0=No, 1=Yes

If YES on Qn. 3.8 and/or 3.9, what is your perception on extension and/or veterinary services? complete the table below

Perceptions on vet/ext services	How would you rsepond 1=Agree; 2=Disagree; 3=Not sure
C21	C22
Quality (The services received from veterinary and/or extension officers were reliable)	
Timeliness (The veterinary and extension officers always came on time when needed)	
Cost effective (The services received from veterinary and/or extension officers were affordable)	

Have you or any other member of the household received any training on livestock management within the last one year? [C23] [___] 0=No, 1=Yes

3.10 If YES (Qn. 3.7) complete the table below

Type of training received	Who offered the training? (*give more than one choice)* CODE A	Who in the household was trained?CODE B

C24	C25a	C25b	C25c	C26
Tsetse fly/trypanosomias management				
Other livestock disease and pest management				
Livestock breeding				
Livestock and livestock products marketing				
Other specify				

CODE A			CODE B	
1. ICIPE 2. CORPs 3. Govt extension agent 4. Farmer Coop/Union	5. Farmer group 6. NGO	7. Agro dealer 8. Fellow farmers 10. Other, Specify….....	1.Household head 2.Spouse 3. Household head and spouse jointly 4. Other male member of the family	

MODULE 4: HOUSEHOLD ASSETS

4.1 Production equipment and major household furniture

Asset Category	*Asset type*	Does the household own? 1= Yes 0=No	Total owned by Household
D1	D2	D3	D4
Farm implements	Sickle		
	Hoe		
	Spade or shovel		
	Axe		
	Knapsack sprayer		
	Ox-plough		
	Water pump (manual)		
	Water pump (motorized)		
	Tractor		
	Wheelburrow		
	Panga/slasher/ hedge cuuter		
Transport	Horse/mule cart		
	Donkey/oxen cart		
	Horse/mule saddle		

Asset Category	*Asset type*	Does the household own? 1= Yes 0=No	Total owned by Household
	Push cart		
	Bicycle		
	Motorbike		
	Car		
Household Furniture	Improved charcoal/wood stove		
	Kerosene stove		
	Water carrier		
	Fridge,		
	Table, sofas, chairs, and beds		
Communication	Radio		
	Mobile phone		
	Cassette or CD player		

4.2 Land and its charateritics

Please provide the following information about the land used by the household in the last 12 months (also include rented land and fallow / grazing land)

	Total agricultural cultivated land			Own land left fallow	Grazing land			Rented out	Who in the household makes decisions on
	Own land	Gift	Rented-in		Own	Rented-in	Obtained as gift		

		land							renting in/out land (CODEA)
D5	D5a	D5b	D5c	D6	D7a	D7b	D7c	D8	D9
Acres									

CODE A	
1.Household head	6. Male worker
2.Spouse	7.Female worker
3. Household head and spouse jointly	8.Others (specify)
4. Other male member of the family	
5. Other female member of the family	

MODULE 5: ACCESS TO CREDIT, SOCIAL CAPITAL, NETWORKING AND HOUSEHOLD INCOME

5.1 Household credit need and sources during last 12 months

5.1.1 Did the household apply for credit or loan in the last 12 months for agricultural production purpose? [E1] [_____] 0=No 1=Yes

5.1.2If YES, from which sources [E2] (CODE A) [_____] [_____] [_____]

CODE A	
1. Bank	6. Microfinance
2. SACCO	7. Development group
3. Farmer groups	8.Mobile phone loan lenders
	9.Others (specify)

5.1.3 If NO, why? [E3] (CODE A) [_____] [_____] [_____] [_____]

CODE A			
1=Borrowing is risky	4=Expected to be rejected, did not try	6=No money lenders in this area for this purpose	8=No credit association
2=Interest rate is high			9=Not available on time
3=Too much paper work/ procedures	5=I have no asset for collateral	7=Lenders don't provide the amount needed	10=Other, specify……

5.2 Social Capital

5.2.1 Is household head or spouse a member of a livestock production and/or marketing group? [E4] [_____] 0=No 1=Yes

5.2.2 If yes, how many groups? ….....

5.2.3 Is household head or spouse a member of any other rural group? [E5] [_____] 0=No 1=Yes

5.2.4 If yes, how many groups? ….....

5.3 Other Social networking

5.3.1 How many years have you been living in this village? (no of years) ….....

5.3.2 Number of people within and outside village that you can rely on in times of critical needs….....

5.3.3 Do you have relatives who have official position in government whom you can rely on in times of critical needs? [E6] 1=yes; 0=no….....

5.3.4 Do you believe that people in your neighborhood would work together to fight common problems [E7] _____ (1=yes, 0=no)

5.3.5 Do you believe that people in your neighborhood know each other well [E8] _____ (1=yes, 0=no)

5.4 Household's off-farm and on-farm income

Income source	Does the household earn income? 0=No; 1=Yes	How much cash is earned per month (KES)
E9	E10	E11
1. Household onfarm income		
2. Household off-farm income		

MODULE 6: INTEGRATION COMMUNITY IN DEVELOPMENT PROGRAMS AND RESOURCE MANAGEMENT

6.1 Has the community, through its members or local leaders, been integrated before in development programs or management of natural resources in any of the following? (*Use table below)*

Program	Were members of community integrated? 0=No; 1=Yes
F1	F2
1. Crop production	
2. Crop pests and diseases	
3. Livestock production	
4. Animal health	
5. Human health	
6. Environmental conservation management	
7. Wildlife protection	
8. Water management	
10. Others (specify)	

6.2 If yes to any of the options in 6.1, what were the challenges/weaknesses with the programs? [F3] (CODE A) [_____] [_____] [_____]

Code A	
1. The community was not involved in recruiting members to be integrated in the programs 2. The programs worked with only a few community members 3. The programs did not address the real challenges 4. The programs did not offer long term solutions	5. Lack of continuity after closure 6. Others (specify)

INTEGRATING COMMUNITIES IN MANAGEMENT OF TSETSE AND TRYPANOSOMIASIS

International Center for Insect Physiology and Ecology (ICIPE) and other partners are proposing integration of community-owned resource persons (CORPs) in Tsetse and trypanosomiasis management programs in our communities. The plan is to recruit, train and retain them within the community. This is believed to be vital in facilitating transfer of knowledge and technologies on control and management of tsetse and trypanosomiasis in the community. They will facilitate access to drugs and veterinary services, and teach farmers on drug administration, use of repellent colors and setting of traps.

6.3 Do you think integrating CORPs in Tsetse flies and trypanosomiasis management will help manage the disease and reduce the losses to farmers? [F4] (Use codes below) [_____]

1 = Strongly agree; 2 = Somewhat agree; 3 = Not agree; 4 = Not sure

6.4 Would you recommend integration of CORPs in trypanosomiasis and management control methods and programs? [F5] [_____] 0=No 1=Yes

6.5 If CORPs are to be integrated in tsetse and trypanosomiasis control and management, how important are the following CORP attributes?

Attributes of the CORP	How important: 1 = Very Important; 2 = Somewhat Important; 3 = Not Important; 4 = Not sure
F6	F7
Age of CORP	
Gender of CORP	

Societal status of the CORP	
Recruitment process for the CORP	
Who should train the CORPs	

6.6 Do you think that the CORP must meet the following characteristics?

	What do you think? 0=No 1=Yes
F8	F9
Must be a resident within this community	
Must have completed at least secondary school education	
Must be a farmer facing the same tsetse and trypanosomiasis challenges as you	
Must be married	
Must be a believer (christian or muslim)	

6.7 If CORPs were to be introduced in this area/village, do you think the following factors would in any way boost or affect their operations?

	What do you think:0=No 1=Yes
F10	F11
Employing CORPs on a longterm basis	
State of communication networks	
State of roads	
CORPs working as both animal and human health campions	

Level of education of the CORPs	
The CORP must be a permanent resident in this area	
Incoporating environmental conservation in CORP training	

Appendix 3: Choice Experiment Efficient Design Syntax

;alts = alt1, alt2

;rows = 24

;block = 6

;eff = (mnl,d)

;model:

U(alt1) = b1[-0.06]*x1[0,1,2]+b2[0.34]*x2[0,1]+b3[0.78]*x3[0,1]+b4[0.94]*x4[0,1]+b5[-0.16]*x5[0,1,2]+b6[-0.003]*x6[0,1,2]/

U(alt2) = b1 *x1 +b2 *x2 +b3 *x3 +b4 *x4 +b5 *x5 +b6 *x6$

Appendix 4: List of all choice sets used in the CE survey

Now I will show you various combinations/scenarios of CORP attributes. Kindly compare the options and indicate which ones you prefer. Each farmer/respondent should consider the scenarios and make choices independently.

The CE design is grouped into 6 profiles with four scenarios per profile. Each profile has to be shown to the same number of respondents (50) during the survey. Threfore every profile containing 50 farmers will be subjected to a specific village/block. Each village will have a sample size of 50 farmers. This means that the total sample size of this survey is 300 farmers

Profile 1

Scenario 1

Attributes	alt1	alt2	Neither 1 nor 2
Age	old (≥50 years)	young (20 – 35 years)	
Gender	Female	Male	
Societal status	Not a leader in the community	leader in the community	
Recruitment process	Community involved	Community not involved	
Who should train the CORPs	County Govnt	Local CBOs	
CORP montly fee	200	600	

Choice question: Which Alternative of CORP would you choose?			

Scenario 2

Attributes	alt1	alt2	Neither 1 nor 2
Age	Middle (36 – 49 years)	Middle (36 – 49 years)	
Gender	Female	Male	
Societal status	Leader in the community	Not a leader in the community	
Recruitment process	Community involved	Community not involved	
Who should train the CORPs	Local CBOs	County Gvnt	
CORP montly fee	400	400	
Choice question:			

Scenario 3

Attributes	alt1	alt2	Neither 1 nor 2
Age	Middle (36-49 years)	Middle (36-49 years)	
Gender	Male	Female	
Societal status	Not a leader in the community	A leader in the community	
Recruitment process	Community not involved	Community involved	
Who should train the CORPs	International NGOs	International NGOs	
CORP montly fee	600	200	

Choice question:			

Scenario 4

Attributes	alt1	alt2	Neither 1 nor 2
Age	Young (20-35 years)	old (≥50 years)	
Gender	Female	Male	
Societal status	A leader in community	Not a leader in community	
Recruitment process	Community not involved	Community involved	
Who should train the CORPs	County Govnt	Local CBOs	
CORP montly fee	600	200	
Choice question:			

Profile 2

Scenario 1

Attributes	alt1	alt2	Neither 1 nor 2
Age	Young (20 – 35 years)	Old (≥50 years)	
Gender	Male	Female	
Societal status	A leader in the community	Not a leader in the community	
Recruitment process	Community not involved	Community involved	
Who should train the CORPs	International NGOs	International NGOs	
CORP montly fee	400	400	
Choice question:			

Scenario 2

Attributes	alt1	alt2	Neither 1 nor 2
Age	old (≥50 years)	young (20 – 35 years)	
Gender	Male	Female	
Societal status	Leader in the community	Not a leader in the community	
Recruitment process	Community not involved	Community involved	
Who should train the CORPs	Local CBOs	County Govnt	
CORP montly fee	200	600	
Choice question:			

Scenario 3

Attributes	alt1	alt2	Neither 1 nor 2
Age	old (≥50 years)	young (20 – 35 years)	
Gender	Male	Female	
Societal status	Not a leader in the community	A leader in the community	
Recruitment process	Community not involved	Community involved	
Who should train the CORPs	County Govnt	Local CBOs	
CORP montly fee	600	200	
Choice question:			

Scenario 4

Attributes	alt1	alt2	Neither 1 nor 2
Age	middle (36 – 49 years)	middle (36 – 49 years)	
Gender	Female	Male	

Societal status	Leader in the community	Not leader in the community	
Recruitment process	Community involved	Community not involved	
Who should train the CORPs	Local CBOs	County Govnt	
CORP montly fee	400	400	
Choice question:			

Profile 3

Scenario 1

Attributes	alt1	alt2	Neither 1 nor 2
Age	middle (36 – 49 years)	middle (36 – 49 years)	
Gender	Male	Female	
Societal status	Leader in the community	Not a leader in the community	
Recruitment process	Community not involved	Community involved	
Who should train the CORPs	International NGOs	International NGOs	
CORP montly fee	400	400	
Choice question:			

Scenario 2

Attributes	alt1	alt2	Neither 1 nor 2
Age	middle (36 – 49 years)	middle (36 – 49 years)	
Gender	Female	Male	
Societal status	Leader in the community	Not leader in the	

		community	
Recruitment process	Community involved	Community not involved	
Who should train the CORPs	International NGOs	International NGOs	
CORP montly fee	400	400	
Choice question:			

Scenario 3

Attributes	alt1	alt2	Neither 1 nor 2
Age	middle (36 – 49 years)	middle (36 – 49 years)	
Gender	female	male	
Societal status	Not a leader in the community	A leader in the community	
Recruitment process	Community not involved	Community involved	
Who should train the CORPs	International NGOs	International NGOs	
CORP montly fee	400	400	
Choice question:			

Scenario 4

Attributes	alt1	alt2	Neither 1 nor 2
Age	middle (36 – 49 years)	middle (36 – 49 years)	
Gender	Male	Female	
Societal status	Leader in the community	Not leader in the community	
Recruitment process	Community involved	Community not involved	

Who should train the CORPs	International NGOs	International NGOs	
CORP montly fee	400	400	
Choice question:			

Profile 4

Scenario 1

Attributes	alt1	alt2	Neither 1 nor 2
Age	young (20 – 35 years)	old (≥50 years)	
Gender	Male	Female	
Societal status	Not a leader in the community	Leader in the community	
Recruitment process	Community involved	Community not involved	
Who should train the CORPs	County Govnt	Local CBOs	
CORP montly fee	400	400	
Choice question:			

Scenario 2

Attributes	alt1	alt2	Neither 1 nor 2
Age	young (20 – 35 years)	old (≥50 years)	
Gender	Male	Female	
Societal status	Not a leader in the community	Leader in the community	

Recruitment process	Community involved	Community not involved	
Who should train the CORPs	County Govnt	Local CBOs	
CORP montly fee	200	600	
Choice question:			

Scenario 3

Attributes	alt1	alt2	Neither 1 nor 2
Age	old (≥50 years)	young (20 – 35 years)	
Gender	Female	Male	
Societal status	Not a leader in the community	Leader in the community	
Recruitment process	Community involved	Community not involved	
Who should train the CORPs	International NGOs	International NGOs	
CORP montly fee	600	200	
Choice question:			

Scenario 4

Attributes	alt1	alt2	Neither 1 nor 2
Age	middle (36 – 49 years)	middle (36 – 49 years)	
Gender	Male	Female	
Societal status	Not a leader in the community	Leader in the community	
Recruitment process	Community involved	Community not involved	
Who should train the CORPs	Local CBOs	County Govnt	

CORP montly fee	200	600	
Choice question:			

Profile 5

Scenario 1

Attributes	alt1	alt2	Neither 1 nor 2
Age	young (20 – 35 years)	old (≥50 years)	
Gender	Female	Male	
Societal status	not a leader in the community	leader in the community	
Recruitment process	Community not involved	Community involved	
Who should train the CORPs	Local CBOs	County Govnt	
CORP montly fee	200	600	
Choice question:			

Scenario 2

Attributes	alt1	alt2	Neither 1 nor 2
Age	old (≥50 years)	young (20 – 35 years)	
Gender	Male	Female	
Societal status	Leader in the community	Not a leader in the	

		community	
Recruitment process	Community not involved	Community involved	
Who should train the CORPs	County Govnt	Local CBOs	
CORP montly fee	200	600	
Choice question:			

Scenario 3

Attributes	alt1	alt2	Neither 1 nor 2
Age	young (20 – 35 years)	old (≥50 years)	
Gender	Male	Female	
Societal status	Not a leader in the community	Leader in the community	
Recruitment process	Community involved	Community not involved	
Who should train the CORPs	Local CBOs	County Govnt	
CORP montly fee	600	200	
Choice question:			

Scenario 4

Attributes	alt1	alt2	Neither 1 nor 2
Age	young (20 – 35 years)	old (≥50 years)	
Gender	Female	Male	
Societal status	Not a leader in the community	Leader in the community	

Recruitment process	Community involved	Community not involved	
Who should train the CORPs	Local CBOs	County Govnt	
CORP montly fee	200	600	
Choice question:			

Profile 6

Scenario 1

Attributes	alt1	alt2	Neither 1 nor 2
Age	young (20 – 35 years)	old (≥50 years)	
Gender	Female	Male	
Societal status	Leader in the community	Not a leader in the community	
Recruitment process	Community not involved	Community involved	
Who should train the CORPs	County Govnt	Local CBOs	
CORP montly fee	600	200	
Choice question:			

Scenario 2

Attributes	alt1	alt2	Neither 1 nor 2
Age	old (≥50 years)	young (20 – 35 years)	
Gender	Male	Female	

Societal status	Leader in the community	Not a leader in the community	
Recruitment process	Community not involved	Community involved	
Who should train the CORPs	Local CBOs	County Govnt	
CORP montly fee	600	200	
Choice question:			

Scenario 3

Attributes	alt1	alt2	Neither 1 nor 2
Age	old (≥50 years)	young (20 – 35 years)	
Gender	Female	Male	
Societal status	Leader in the community	Not a leader in the community	
Recruitment process	Community not involved	Community involved	
Who should train the CORPs	County Govnt	Local CBOs	
CORP montly fee	200	600	
Choice question:			

Scenario 4

Attributes	alt1	alt2	Neither 1 nor 2
Age	old (≥50 years)	young (20 – 35 years)	
Gender	Female	Male	
Societal status	Not a leader in the community	Leader in the community	
Recruitment process	Community involved	Community not involved	
Who should train the	International NGOs	International NGOs	

CORPs			
CORP montly fee	600	200	
Choice question:			

6.9 Validation Questions on Choice Experiment Responses

6.9.1 How sure are you about the CORP choices you made? [F12] [_____]

[1] = Very sure, [2] = Sure, [3] = probably sure, [4] = Not sure

6.9.2 Were you considering and comparing attributes before you made a choice? [F13] [_____] 0= No, 1 = Yes

6.9.3 Are there specific attributes that you were looking for in each choice option before you made each decision? [F14] [_____] 0 = No, 1 = Yes

6.9.4 If yes to Qn 6.6.3, specify the selected attributes.[F15] (CODE A) [_____] [_____] [_____]

CODE A	
1. Age of CORP	4. Recruitment process for the CORP
2. Gender of CORP	5. Who to train the CORP
3. Societal status of CORP	6. CORP mothly fee

6.9.5 What is your opinion on the attributes and choice options provided in this survey?

Opinion on attributes	1=Agree; 2= Disagree; 3=Not sure
F16	F17
1. Attributes were too many	
2. Attributes were too few	
3. Choice options were too many	
4. Choice options were too few	
5. Attributes were familiar	
6. Choices were easier to make	
7. Attributes were relevant for a CORP	