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Kerstin Katharina Zander





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Abstract

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Given the diminishing diversity within farm animals and with it dwindling genetic resources that are in jeopardy of becoming extinct forever, sound conservation programmes for farm animal genetic resources become more and more important, including appropriate compensation payments for community-based conservation programmes. The findings of this study will guide policy-makers in their decisions on which breed to conserve, where to conserve and how to conserve it, all under the umbrella of cost-efficiency. The survey was limited to the Borana breed in southern Ethiopia and northern Kenya.

The first scope of this study was to discover (1) unique benefits of and threats to the Borana breed and, (2) the distribution and existence of Borana subtypes. This study aimed to monetarily assess (3) attributes of local cattle breeds in the research area and, (4) different cattle breeds *per se* relative to each other. A further objective of this study was to reveal (5) the costs of a community-based *in-situ* conservation of the pure Borana. Finally, the study aimed to identify (6) a ranking priority for the conservation of different Borana subtypes and, (7) important implications and considerations for conservation programmes.

Overall, the study concludes that comparing the values of three locally adapted Borana subtypes (Ethiopian Borana (EB), Orma Borana (OB) and Somali Borana (SB)) to the costs of conserving them, conservation programmes will have great potential and will secure the Borana people's daily needs as well as their traditional pastoral lifestyle that is strongly interdependent with the keeping of Borana cattle. It was further concluded by applying a Weitzman priority ranking approach that the EB has the greatest potential to be conserved cost-efficiently and that this type in Ethiopia should receive the highest priority for conservation funding. With properly installed community-based *in-situ* conservation programmes, a rapid change in production and land use systems away from a sustainable cattle husbandry production can be haltered. Conserving the EB in the Borana lowlands in Ethiopia will secure the future use of the Borana genetic material at very little costs per animal.

Keywords: animal genetic resources, Borana, choice modelling, compensation payments, conservation, Weitzman

Kurzfassung

Modellierung des Wertes tierischer genetischer Ressourcen – Festlegung von Prioritäten für Erhaltungsmaßnahmen des Borana-Rindes in Ostafrika

Kerstin Katharina Zander

Diese Arbeit beschäftigte sich mit der ökonomischen Bewertung tierischer genetischer Ressourcen und der Frage nach einer möglichst kosteneffizienten Erhaltungsmaßnahme für das Borana-Rind in Kenia und Äthiopien. Zur Datenerhebung wurden im Zeitraum zwischen Juni 2003 und September 2004 370 Rinderhalter in Nordkenia und Südäthiopien interviewt.

Landwirtschaftliche Produktion hängt überwiegend nur noch von wenigen Nutztierrassen ab. Viele Rassen, die früher der Nahrungsmittelsicherheit dienten, sind bereits ausgestorben. Mit der Dezimierung der Rassen vermindert sich sogleich ihr genetisches Material und somit wichtiges Züchtungsmaterial für die Zukunft. Obwohl das Borana-Rind sich durch viele hervorragende Eigenschaften auszeichnet, schwindet auch sein genetisches Material, zum einen durch einen generellen Rückgang der Rinderpopulationen im Untersuchungsgebiet (aufgrund von Dürren, Wechsel zu anderen Produktionssystemen, begrenzte Weideflächen) und zum anderen durch intensive Kreuzungen mit anderen einheimischen und zum Teil auch „exotischen“ Rassen.

Eine phänotypische Erhebung der Verteilung des Borana-Rindes im Untersuchungsgebiet zeigte, dass drei Unterarten dieser Rasse dominieren, welche alle drei mögliche Kandidaten für Erhaltungsmaßnahmen wären: das Äthiopische Borana-Rind (EB), das Orma-Borana-Rind (OB) und das Somalische Borana-Rind (SB). Diese Arbeit beschäftigt sich daher mit den Fragestellungen, welche der drei Unterarten erhalten werden soll, wie viele Tiere davon erhalten werden müssten, wo es erhalten werden solle, welche Rinderhalter einbezogen werden sollten und wie hoch die Kosten wären.

Das Weitzman-Ranking ergab, dass es kosteneffizient wäre, das EB *in-situ* in Äthiopien zu erhalten. Die Studie zeigte, dass die finanzielle Mittel die dafür bereitgestellt werden müssten im Gegensatz zu dem ernormen Wert und Nutzen des Rindes sehr gering sind.

Schlüsselworte: Borana-Rind, Entschädigungszahlungen, Erhaltungsmaßnahmen, tierische genetische Ressourcen, diskretes Wahlmodell, Weitzman

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Abbreviations and Acronyms

Acronym	**Definition**
AnGRs	Animal genetic resources
ASC	Alternative specific constant
CBD	Convention On Biological Diversity
CE	Choice experiment
CGRFA	Commission of Genetic Resources for Food and Agriculture
COS	Compensating surplus
COV	Compensating variation
CR	Choice ranking
CS	Consumer’s surplus
CV	Contingent valuation
CVM	Contingent valuation method
DAD-IS	Domestic Animal Diversity Information System
DAGRIS	Domestic Animal Genetic Resources Information System
EB	Ethiopian Borana
ED	Experimental design
ES	Equivalent surplus
EV	Equivalent variation
FAnGs	Farm animal genetic resources
FAO	Food and Agriculture Organization of the United Nations
GM	Gross margin
GMA	Gross margin analysis
HH	Household
HHH	Head of household
IIA	Independence from irrelevant alternatives
IID	Independently and identically distributes
ILRI	International Livestock Research Institute
IUCN	International Union for Conservation of Nature and Natural Resources = World Conservation Union
IV	Inclusive value
KARI	Kenyan Agricultural Research Institute
KB	Kenyan Borana
KSH	Kenyan Shillings

LL (LK)	Lok-likelihood
LU	Livestock unit
MLE	Maximum likelihood estimation
MNL	Multinomial logit
MXL	Mixed logit model
N	Number of observations
OB	Orma Borana
OC	Opportunity costs
OECD	Organization of Economic Cooperation Development
PA	Peasant association
QTL	Quantitative trait loci
RUM	Random utility model
SB	Somali Borana
SEAZ	Small East African Zebu
SPSS	Statistical Package for the Social Sciences
SRS	Simple random sampling
SORDU	The Southern Rangelands Development Project
TEV	Total economic value
UN	United Nations
UNEP	United Nations Environmental Programme
WFP	World Food Programme of the United Nations
WTA	Willingness to accept
WTP	Willingness to pay
WWL-DAD	World Watch List for Domestic Animal Diversity

CHAPTER ONE

General Introduction

1. General Introduction

This work focuses on livestock biodiversity and is in particular concerned with the economic aspects of conservation initiatives for animal genetic resources (AnGRs). Cattle and more precisely the Borana breed in East Africa were selected as case study. This introductory chapter clarifies the motivation for this study, which is driven, on the one hand, by the immense importance of livestock and particularly local cattle breeds in marginal areas and production systems and, on the other hand, by the increasing threat they have to face.

1.1. Importance of livestock in developing countries

Livestock has always contributed to the satisfaction of many needs, dating back as far as the primeval age (Blackburn, 1998) with domestication having started during the Mesolithic period around 8000–7000 BC (Zeuner, 1963). Unlike in developed countries, where the dependence on livestock decreased mainly due to industrialisation, livestock still serves as a vital tool for the majority of the population in developing countries. Around 2 billion people in developing countries depend at least partly on farm animals for their livelihood (FAO, 2000). Domestic farm animals not only provide 30 to 40 percent of the agricultural sector's global economic value, (in sub-Saharan Africa even almost 50 percent (Winrock International, 1992)), but also grant many direct and indirect benefits to the rural population. First of all, livestock serves as a reliable opportunity for agricultural intensification to cater for the **food** requirements of a population which, particularly in developing countries, is accelerating at a fast rate[1] (Delgado et al., 1999). Farm animals are important sources particularly for protein which is needed in daily dietary requirements. Secondly, livestock has many non-food functions such as the provision of **manure** (for cooking, building and as fertilizer), hides, transportation and most importantly **draught power**. Only the use of livestock and its draught power enable the cultivation of large and inaccessible areas and compensate for the lacking availability of modern agricultural machineries (Blackburn, 1998). The latter fact clearly highlights the importance of the livestock's draught power particularly for Sub-Saharan countries where 54 percent of the land is classified as either arid or semiarid (Jahnke, 1982). Besides these direct food and non-food benefits, livestock contributes to social and traditional structures, even forming the root of many societies' **cultural identity**. Finally, livestock provides capital stock with **insurance** functions. Small stock (e.g. goats and

[1] The changes in dietary patterns and the hence growing demand for meat, milk and eggs result from increasing urbanisation and rising income and has been predicted to become 63 percent greater in 2020 than in it was in 1993, with a 88 percent increase in less-developed countries (Delgado, 2000; CAST, 1999).

sheep) is believed to serve as "cash money" whereas big stock such as cattle and camels usually stay in stock as insurance, buffering against climatic and market risks, and are only sold in emergency cases. Particularly in rural areas is livestock an important year-round source of **cash**, and is thus crucial for the **purchase of consumer goods** and procurement of farm inputs (Rege and Gibson, 2003).

Cattle make a very large number of important contributions to food and agriculture and are considered the most important species among livestock with particular importance in the lowland areas of African countries where pastoral systems have prevailed for many centuries. On the whole, cattle provide nearly 30 percent of the world's **meat** and approximately 90 percent of the world's **milk** production (FAO, 2000, p. 9) comes from cattle and buffaloes. The bigger number of heads of cattle is kept in developing countries, namely about 70 percent of the worldwide cattle population (ILRI, 2000). Ethiopia is home to the largest cattle population in East Africa with app. 29.5 million heads which represents almost 30 percent of the total population of cattle in East Africa of roughly 90 million heads (ILRI, 2000). In Kenya, roughly 12.5 million cattle are kept (as a comparison, it has been estimated that there are 1.3 billion cattle worldwide) (ILRI, 2000; ILRI, 2006a; FAO, 2004). The husbandry of Borana cattle in Kenya and Ethiopia is strongly linked to the **nomadic production system** and lifestyle that is only feasible due to Borana cattle breeding. This mutually **interdependency** between the traditional lifestyle and animals highlights the importance of Borana cattle production in the research area.

1.2. Degradation of AnGRs

However, despite these various benefits, livestock populations are facing many threats causing erosion in, and finally irreversible loss of their genetic resources. According to FAO (1999), 16 percent of farm animal breeds have been lost since the turn of the last century and a further 30 percent are currently at risk of becoming **extinct**, with the rate of extinction continuously accelerating (Hall and Ruane, 1993). Nevertheless, **missing data** hampers a reliable classification of many local breeds and thus many breeds are declared as being "not at risk" only due to the fact that data is not available. This also holds true for the Borana cattle breed in east Africa, which has formally not been declared as being endangered. Nevertheless, the data upon which this classification was decided is not reliable and hence more research is necessary. In developing countries, where livestock production is characterised by the **absence of herdbooks**, conservation initiatives rather aim to ensure purity of breeding animals because even if a breed (like the Borana cattle) is not classified as endangered, there are various threats to the purity of these animals resulting in genetic erosion.

The **extinction share** for cattle lies at an alarmingly 22 percent (Rege, 1999a) for those that have gone extinct in the last 100 years and 27 percent for the remainder at various degrees of risk. From these extinct breeds 70 percent are in developing countries (Rege and Gibson, 2003). Particularly low-yielding indigenous livestock breeds are in jeopardy of becoming extinct as a result of changing **production systems** and **market structures** (Koehler-Rollefson, 2000) with the trend going towards **increased intensification** and industrialisation of production systems based on **uniform genetic resources**. These changes in production systems have manifold effects on AnGRs, such as a general decline in livestock numbers when switching to crop-production as a main means of income generation or the replacement of one species by another. Genetic dilution or eradication of genetic material of local breeds through the use of **exotic germplasm**[2] (Rege and Gibson, 2003) or through the **interbreeding** with other local breeds is also to a large degree due to changing production systems. Artificial insemination (AI) services are often free of charge and provide local farmers access to exotic genotypes at lower cost than would apply for AI of local breeds, if it was available (FAO, 2000, pp. 556). The use of AI is often linked with **governments** promoting large-scale entrepreneurs and crossbreeding with exotic breeds. Breeds that are of major significance to the poor are largely ignored by the government and often do not receive support for improvement programs (Koehler-Rollefson, 2000). Market forces and adverse governmental support encourage farmers to abandon unprofitable breeds in favour of more economically attractive alternatives. Hence, some breeds will no longer be the most profitable choice by farmers. Adverse policies in restocking measurements with inferior Highland breeds after droughts also contribute to further genetic dilution of the Borana and to the general suppression of Borana animals.

Other factors that eventually lead to dwindling AnGRs are **population pressure** and declining availability of **pasture** which necessarily comes along with it (again forcing livestock-keepers to change their production systems). Frequently recurring **droughts** and **cultural clashes** with looting of cattle can cause losses in local cattle breeds and precious genetic resources as well, and, not only in the case of the Borana breed, but also with respect to other local breeds and other species falling victim to droughts or other natural disasters. Despite these facts, until now biodiversity is frequently linked to plant diversity and wildlife diversity, leaving out the issue of farm animal (genetic) diversity. The **gene pool** in AnGRs is

[2] One example of exotic germplasm would be the import of reproduction sires of breeds used for meat purpose and then being interbred with cows of local breeds. That example happened with Hereford bulls that were imported and then interbreed with Borana cows in Central Kenya. Another example would be the import of North American Holstein Friesian cows for milk production often having replaced other local dairy breeds entirely.

much smaller than in crops (Rege and Gibson, 2003) and thus erosion in AnGRs is much more serious.

A loss in animal genetic diversity in traditional breeds[3] will, of course, weaken the chances of **future** generations to respond adequately to increasing food demand, potential environmental changes, diseases, and other challenges and catastrophes we cannot foresee (Koehler-Rollefson, 2002) Conserving AnGRs can therefore be regarded as a "massive past **investment** which, if managed appropriately, can provide insurance against unknown global future" (Rege and Gibson, 2003, p. 322) because these AnGRs contain the genetic potential for "new" or "improved" breeds tolerant or resistant to biotic and abiotic stress factors. Hence, diversity in AnGRs constitutes an essential aspect of **sustainable animal production** and **food security** for the growing world population (Drucker et al., 2001; Koehler-Rollefson, 2002). Lastly, the maintenance of diversity in AnGRs fosters global biodiversity (Rege and Gibson, 2003).

1.3. Importance of conserving biodiversity in cattle breeds

In 1992 the United Nations passed the "Convention on Biological Diversity" (CBD) (CBD, 1992), delivering the platform for international strategies, plans and programs for the conservation and sustainable use of biological diversity[4]. The CBD was a first step in recognising the immense significance of global biodiversity and its endangered state. A further important step was the recognition of AnGRs by the Commission on Genetic Resources for Food and Agriculture (CGRFA)[5] in 1997. However, many developed countries are still neglecting this threat and have contributed to a massive decline in the number of species used nowadays for agricultural production.

There are only slightly more than 40 domestic livestock species commonly used in farming systems (Barker, 1999; FAO, 2000, p. 7). They are the source of 30 to 40 percent of the total value of food and agriculture production. Globally, domestic AnGRs constitutes 30 percent of total human requirements for food and agricultural production (FAO, 1999). Only 14 of these 40 domesticated species contribute to 82 percent of the world's food and agriculture production with a large range of species in the family Bovinae as major food suppliers (Barker, 1999; FAO, 2000). These figures reveal a clear discrepancy in production yields

[3] Traditional breeds are also referred to as local, indigenous or "old" breeds. The meaning is the same in all cases.

[4] Biological diversity is often simply referred to as biodiversity.

[5] In the 7th Session of the CGRFA in May 1997, a subsidiary Intergovernmental Technical Working Group on Animal Genetic Resources (ITWG-AnGR) was established to address issues relevant to the conservation and sustainable use of AnGRs for food and agriculture (CGRFA, 2004).

within domesticated species. Over the last 12,000 years these 14 species have been domesticated and have evolved into separate and genetically unique breeds adapted to their local environments and community requirements. There are some 6 000 to 7 000 domestic breeds remaining. These breeds and the species they represent, together with approximately 80 species of wild relatives, comprise the world's AnGRs[6] important for food and agriculture (FAO, 2000, p. 22) and this diversity should be preserved.

Along with the **potential economic use** in the future, the reasons for conserving diversity in AnGRs are manifold, including **scientific use** and **cultural interests** (FAO, 1999). Local cattle breeds kept in pastoral systems also contribute to environmental and **landscape benefits**. These cattle are sometimes the only live animals that can make use of the harsh and meagre system of the deserted East African lowlands. Without cattle these landscapes would be completely abandoned. In areas where crop production is feasible to a small extent, AnGRs are vital to the **economic development** because of their important role in the subsistence of many communities and the sustainability of crop-livestock systems.

A further reason for protecting local and sometimes unprofitable cattle breeds is that they reflect a **traditional way of life** that a culture wishes to keep intact and often form the basis of society's traditional systems. Domestic cattle diversity is mainly the result of "natural" *in-situ*[7] conservation, in which communities of livestock-keepers manage their AnGRs according to their own preferences and needs (Anderson, 2003). Traditional breeds were thus developed over time in traditional societies without herd books and "scientific" (at least in the Western sense) interventions (Koehler-Rollefson, 2002) but by relying on livestock-keepers' **indigenous knowledge** in terms of breeding strategies and production systems. The purpose of domestication and selection by humankind, eventually resulting in certain new breeds in response to environmental change, disease threats, consumer demand, changing market conditions and societal needs, was to ensure the sustainability of human communities (FAO, 2000). A loss in AnGRs diversity would halter these benefits of centuries of domestication.

There are also many breeds which may be conserved for their **aesthetic value** and a final motivation for maintaining unprofitable and rare AnGR is **existence value**, i.e. some people

[6] The term AnGRs includes all animal species, breeds and strains that are of economic, scientific and cultural interest to humankind for the purpose of food and agricultural production (Rege and Gibson, 2003).

[7] *In-situ* (in the field of AnGRs also referred to as "on-farm") conservation is defined by the Convention On Biological Diversity (CBD) as the conservation of ecosystems and natural habitats, and the maintenance and recovery of viable populations of species in their natural surroundings where they have developed their distinctive properties (CBD, 1992). There are basically two different types of conservation approaches, namely *in-situ* and *ex-situ* conservation. Both methods are detailed in Chapter 2.1.

may want to keep examples of domesticated breeds simply for their own sake. That is, they may be interested in the breeds as historical anomalies or because of aesthetic considerations such as beauty or toughness (Mendelsohn, 2003).

1.3.1. Why value animal genetic resources?

Environmental valuation techniques can provide useful **evidence** to support and justify conservation policies by quantifying the economic value associated with the protection of biological resources. Pearce (2001) argues that the measurement of the economic **value of biodiversity** is a fundamental step in conserving this resource since “the pressures to reduce biodiversity are so large that the chances that we will introduce incentives for the protection of biodiversity without demonstrating the economic value of biodiversity are much less than if we do engage in valuation”. Rege (1999b) pointed out that the need to value the economic diversity of AnGRs to justify their conservation and to **guide policy makers** in finding optimal conservation strategies. These strategies eventually allow **benefit sharing** aiming at the question of “who bears the costs, who obtains the benefits of conserving AnGRs?” (Rege, 1999b). Coming up with “fair” monetary values for cattle breeds might also guide policy-makers in drought periods. The most recent drought that occurred from December 2005 to April/May 2006 in East Africa and to which 80 percent of the animals fell prey, has shown that there is high demand and prospect for sound conservation and restocking management.

Assigning monetary values to biodiversity is thus important since it allows the benefits associated with biodiversity to be directly compared with the economic value of alternative resource use options (Nunes and van den Bergh, 2001). The Organisation for Economic Co-operation and Development (OECD, 2002) also recognises the importance of measuring the economic value of biodiversity and identifies a wide range of uses for such values, including demonstrating the value of biodiversity, in targeting biodiversity protection within scarce budgets, and in determining damages for loss of biodiversity in liability regimes. The absence of an economic value for biodiversity means that conservation initiatives fail to compete in policy decisions and in fund raising issues. Economic valuation of farm AnGRs can counteract the missing awareness towards the conservation of farm AnGRs in terms of its existence and bequest values and eventually match up to wildlife conservation.

The objective of assessing the various values under different perspectives is twofold: first of all, to provide **justification for conserving** the Borana breed and its subtypes, and secondly, to provide better understanding of their **breeding value**. The genetic erosion of a breed may **justify** conservation efforts, even if the breed in question is not yet recognised as being endangered (due to the absence of reliable data), as its loss reduces livestock-keepers' options to maintain sustainable livelihoods and threatens the global diversity of farm AnGRs. The latter occurs when livestock-keepers **react to market** incentives by moving to more **profitable** breeds (often exotic breeds and there admixtures) in order to avoid being left economically worse off. With particular focus on the research area and the conservation of the Borana cattle breed, maintaining the culture must be economically feasible for the Borana clans and, hence, incentives and compensation payments might be required which ,in the end, would facilitate the **diversification** of livestock-keepers' **income** and, primarily, constitute an additional source of income. Economic evaluation facilitates determining the amount of compensation payments that would be possibly needed as additional income for the livestock-keepers (see Chapter 6).

Very few reliable comparisons of local and exotic breeds have been undertaken in developing countries. Economic potential cannot be measured by looking simply at performance. Rare or endangered breeds are often highly adapted and their performance should be measured comparatively within their own environmental conditions and not with animals kept in intensive production systems. Therefore, economic valuation should also aim at **non-market values** (that can be cultural aspects, use of manure etc.) which can be quite diverse and are usually greater for local breeds than for exotic high-yielding breeds. Livestock markets in developing countries are often characterised by **market failures** and hence the "real" values of many breeds are not reflected on the markets but are underestimated. Livestock-keepers living in the research area are characterised by extreme **poverty** and, even if the demand for the pure Borana breed is very high, people simply cannot afford to purchase them and so switch to cheaper cattle breeds.

While the CBD stresses the role of concerted global action, the reality is that global action is only the sum total of actions taken within nation states hosting biodiversity (OECD, 2002). Individual states and regions within states face conflicting priorities in the selection of development paths but valuation on the national level facilitates overcoming this problem. All societies depend on biodiversity and biological resources either directly or indirectly. Their value, however, is predominantly implicit rather than explicit (OECD, 2002). For biodiversity and many biological resources the absence of apparent value combined with absent or poorly defined property rights creates a problem of over exploitation and unregulated use. Biodiversity conservation is often a low priority simply because there are measurement and valuation problems: biodiversity defies easy description and quantification. What cannot be quantified or is difficult to monitor and evaluate is easy to disregard (OECD, 2002).

1.4. Objectives and outline of the study

This study aims at contributing to **decision making** in conservation initiatives for AnGRs and in particular for the Borana cattle breed in Kenya and Ethiopia. The study is further intended to enhance an understanding of two crucial questions that have to be pursued when defining conservation initiatives for AnGRs: the question of **"what"** to conserve and the question of "**how"** the conservation should be carried out. The first question relates to the breed or subtype of breed that should receive priority in conservation, as the competition for scarce funds is tight and not all breeds can be maintained at the same level, if at all (Pearce and Moran, 1994; Cicia et al., 2003). What cattle breeds/subtypes should be given the highest priority depends on what utility they supply to local livestock-keepers (i.e. on their economic values), as well as on their genetic values.

The second question seeks to clarify how the maximal conservation priority can be conserved in the most cost-efficient way. It is widely accepted that *in-situ* conservation is the only reasonable strategy and that maintaining the productions systems where pastoralists and small- scale farmers manage these animals is the most promising way to conserve AnGRs (Hall and Ruane, 1993; League for Pastoral Peoples, 2002). At any rate, details on how *in-situ* conservation should look like have hitherto only been developed on the surface (e.g. how many animals are required for conservation, which should be the sex ratio, which livestock-keepers should participate, etc.). This study seeks to clarify some of the driving factors, eventually deciding about the success of applied conservation strategies and thereby placing great emphasis on **opportunity costs** (OC) of maintaining AnGRs.

It has to be understood that while this study deals with farm animal genetic resources (FAnGRs), its is concerned with the loss of **within breed diversity** due to genetic **dilution** rather than the loss in the number of animals/populations *per se*. Particularly with regard to the Borana breed, it can be stated that this breed is still quite numerous but its unique genetic make-up is in serious jeopardy.

Finally, the **overall value** of Borana as a combined measure of genetic and economic value is issued, using the **Metrick-Weitzman approach**. Genetic parameters such as extinction probability and "pureness of Borana genes" are taken into account whereas the economic values are derived from willingness to pay (WTP) indicators resulting from a conducted choice experiment (CE).

To summarise, this study focuses on the following objectives:

- Recognising threats to the survival of the Borana breed.
- Classifying the distribution of Borana and its subtypes in the research area.
- Classifying values of Borana cattle that might be important for individuals and the society
- Identifying cattle attributes that livestock-keepers particularly associate with the Borana breed.
- Revealing livestock-keepers' WTP for these attributes.
- Identifying heterogeneity in livestock-keepers' socio-economic characteristics with respect to their preferences about cattle attributes, and thereby
- Differentiating among types of livestock-keepers for determining potential participants who can be best targeted for conservation initiatives.
- Inferring from the evaluation of attributes to the evaluation of entire breeds and of different Borana subtypes, and thereby
- Revealing relative differences in the values of these Borana subtypes to local livestock-keepers.
- Determining the OC of substituting various cattle breeds by the Ethiopia Borana subtype as a measure of compensation costs.
- Developing a ranking scheme for conservation priority among Borana subtypes.
- Sketching conservation programmes for Borana cattle based on the available results.

The study is structured in six main chapters. Following **Chapter 1,** which outlines the general introduction, is **Chapter 2,** which discusses the conceptual framework for evaluating AnGRs. In addition, it gives some background about the concepts of conservation strategies, on methods for the evaluation of environmental goods in general as well as on literature hitherto emerged in the context of assessing genetic resources. The framework further highlights the use of discrete choice analysis for assessing cattle attributes and welfare indicators that can be derived from this analysis. **Chapter 3** introduces the Borana society and its cattle, including some genetic aspects of the unique Borana breed and the special threat this breed is facing in Kenya and Ethiopia. **Chapter 4** provides an overview of the study area, data collection procedures and the design procedure for the CE. **Chapter 5** presents the results of the CE, WTP estimates for certain cattle attributes and eventually for "whole breeds", and the presence and magnitude of taste variation among different groups of livestock-keepers. **Chapter 6** comprises an OC analysis for conserving AnGRs by elaborating the question of the substitutability of various breeds/subtypes of cattle. In addition, the feasibility of applying marginal cost analysis for estimating costs of conserving AnGRs are discussed in this chapter. In **Chapter 7**, a ranking scheme for the Borana subtypes is detailed, combining various valuable aspects of cattle breeds such as genetic and economic values. It also gives an overview of livestock-keepers' attitudes towards breeding and conservation issues which can be enlisted for deciding which group of people is best suited (in terms of most willingly) to maintain the breed/subtype in question *in-situ*. Finally, **Chapter 8** provides a number of conclusions and highlights policy implications for the conservation of AnGRs in general and the Borana cattle breed in particular.

CHAPTER TWO

Theoretical framework of the valuation of AnGRs

2. Theoretical framework of the valuation of AnGRs

First of all, this chapter provides background on conservation classification systems functioning as a rough guideline towards which farm animal species are vulnerable and hence should be conserved, and which are not endangered. Secondly, available strategies for conserving farm animals are detailed. Thirdly, welfare measures that can be derived from results given by the applied models will be detailed. This chapter introduces those concepts of evaluation of public goods that are important for the underlying study. That includes stated preference methods such as CEs based on a basic multinomial logit (MNL) model and a modification of it, the mixed logit (MXL) model. The analysts' limitations, of which they should be aware regarding the ability to receive decent results and to make sound interpretations of the outputs, are also explained. Finally the chapter looks at the specifications of the contingent valuation method.

2.1. Background on conservation theory

This chapter gives an overview of the theory behind classification systems defining the degree of endangerment of species or breeds on the one hand and of available conservation strategies on the other hand.

2.1.1. Conservation classification systems

Two classification systems have been developed and commonly used for defining the **risk status** of domestic animals: one by the FAO (1998) and UNEP and the other by IUCN (1980). The classification system by the IUCN is based on threatened wild species **categories** and differs slightly from the FAO definitions of risk for domestic animals as outlined below. The underlying theory for Borana cattle is based on the FAO/UNEP classification and hence, the IUCN classification system[8] will not be discussed further at this point.

The **FAO/UNEP** classification system (FAO, 1998) consists of seven categories: extinct, critical, critical-maintained, endangered, endangered-maintained, not at risk and unknown. The breeds are categorised according to different criteria such as overall population size, number of breeding females, the number of breeding males, the percentage of females bred to males of the same breed and the trend in population size. Further consideration is given to

[8] The IUCN system assigns species to a category indicating the degree of threat. These categories are: extinct, endangered, vulnerable, rare, indeterminate, insufficiently known, threatened and commercially threatened (IUCN, 1980). These categories were initially developed for wild species but could be adopted for domesticated farm animals as well.

whether active conservation programmes are actually being carried out for critical or endangered populations.

A breed is categorised as **extinct** if it is no longer possible to recreate the breed population. This situation becomes non-reversible when there are no breeding males or breeding females left. In reality extinction may be realized well before the loss of the last animal, gamete or embryo (FAO, 1999).

A breed is in **critical** condition if either the total number of breeding females is less than or equal to 100 or the total number of breeding males is less than or equal to five; or if the overall population size is less than or equal to 120 and decreasing and the percentage of females being bred to males of the same breed is below 80 percent.

A breed is classified as **endangered** if one of the four options holds: either the total number of breeding females is greater than 100 and less than or equal to 1000, or secondly, the total number of breeding males is less than or equal to 20 and greater than five, or thirdly the overall population size is greater than 80 and less than 100 and increasing and the percentage of females being bred to males of the same breed is above 80 percent, or finally the overall population size is greater than 1000 and less than or equal to 1200 decreasing and the percentage of females being bred to males of the same breed is below 80 percent. Within this category, breeds may be further categorized as critical-maintained or endangered-maintained. These categories identify critical or endangered populations for which active conservation programmes are in place or populations are maintained by commercial companies or research institutions.

A breed is referred to as **not at risk** if none of the above definitions apply and in case the total number of breeding females and males are greater than 1000 and 20, respectively, or if the population size is greater than 1200, and the overall population size is increasing.

Based on this classification scheme, the World Watch List for domestic animal diversity was initiated. The recent 3rd edition of the World Watch List for Domestic Animal Diversity (WWL-DAD:3) has been largely based on the Global Databank for Farm Animal Genetic Resources, the Domestic Animal Diversity Information System (DAD-IS) which has been developed and maintained by FAO.

2.1.2. Conservations strategies

Conservation in general is the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations (IUCN, 1980). The conservation of FAnGRs refers to all human activities including strategies, plans, policies, and actions undertaken to ensure that the diversity of FAnGRs is maintained to contribute to food and agricultural production and productivity, now and in the future. Having ratified the Convention on Biological Diversity, it is the sovereign prerogative of countries to launch national strategies for the conservation of AnGRs at risk (FAO, 2000, p. 24).

Conservation techniques can be divided into ***in-vivo*** and ***in-vitro*** conservation. *In-vivo* conservation focuses on **live animals** and is further divided into ***in-situ*** and ***ex-situ*** conservation (Simianer, 2005a). ***In-situ*** (also referred to as "on-farm") conservation is defined by the CBD as the conservation of ecosystems and natural habitats, and the maintenance and recovery of viable populations of species in their natural surroundings where they have developed their distinctive properties (CBD, 1992). In other words, *in-situ* conservation is the maintenance of live populations of animals in their adaptive environment or as close to it as is practically possible. ***Ex-situ*** preservation involves the conservation of live animals in a situation removed from their normal habitat or production system, such as in zoos or herds kept in natural protected areas or experimental/research farms (Gandini and Oldenbroek, 1999). However *in-situ* and *ex-situ* approaches are not considered mutually exclusive but can also be used complementarily (Henson, 1992). *In-vitro* conservation refers to **cryoconservation** of genetic material including haploid cells (semen, oocytes), diploid cells (*in-vivo* and *in-vitro* embryos, somatic cells) and DNA. It is widely accepted that in the case of conserving AnGRs, *in-situ* conservation is most beneficial from many points of view (e.g. Hall and Ruane, 1993; League for Pastoral Peoples, 2002). This is because *in-situ* conservation enables populations to adapt to changing environmental conditions and endemic diseases, and thus increases the probability that their genes might be valuable for utilization, in other countries and also in the future. The maintenance of live herds allows for selection and improvement of populations for future needs within the constraints of a changing environment. Furthermore, *in-situ* conservation can be embedded into a community-based conservation approach and is hence most likely to benefit the local livestock-keepers. In case of *ex-situ* conservation, a benefit flow from the involved institutions or the government to the farmers is difficult to achieve and farmers' rights would most likely be left unconsidered. Other key advantages of *in-situ* conservation are firstly, that it does not require much advanced technology as it is often based on indigenous knowledge, secondly, that the animals still contribute to daily income and food supply, and thirdly, that it ensures financial commitments and hence improves the livelihood of livestock-keepers' communities associated with the breeds targeted for conservation. Nevertheless, some scientists argue that the apparent advantage that a live population genetically adapts to changing conditions is often overemphasized, since genetic change due to natural selection is not expected to be very large in only a few generations (Simianer, 2005a).

The major disadvantages of *in-situ* conservation are brought about by a lack of complete control over the many factors which influence the survival of individuals and therefore the genetic makeup of the conserved population. *In-situ* conservation projects require land and people which might be limited resources in some regions of the world. Continuation of all conservation projects is dependent upon unpredictable financial and political situations particularly if they are government or institutionally determined. *In-situ* conservation incurs the possible threat of disease eliminating whole or substantial parts of a conserved population, particularly if the conserved herd is in a single or only a few linked locations. Diseases may also act as a major selection pressure within a population, and may substantially change its characteristics. *In-situ* conservation causes social and private OC of maintaining indigenous breeds instead of adopting modern breeds with higher productivity and hence higher food production etc.

Performing of **cryoconservation** is most commonly done by using **gene banks**. The main advantage of gene banks is that they require little space and few trained technicians. A very large number of frozen animals from a large number of populations can be stored in a single facility. Another benefit of cryoconservation, noticeably contradictory to the advantage of organisms to continuously adapt to the environment when conserved *in-situ*, is that unlike *in-vivo* methods, cryogenically preserved populations suffer no genetic loss due to selection, genetic drift or inbreeding (Simianer, 2005a).Furthermore, frozen AnGRs are said to be easily able to be made available to livestock breeding and research programmes throughout the world.

The principle disadvantages of cryogenic lie in the limited availability of the necessary technology and limited access to the frozen populations. Besides which, cryogenic stores have no value with respect to financial income unless material can be sold for research and development. They do not produce food or other agricultural commodities and might therefore be deemed to be expensive luxuries in periods of financial austerity. The cryogenic method is less effective in the conservation of "breeds" where the relative frequency of genes is important. It is only ideal for the preservation of defined ‘genes’ or recognized characteristics. There is a potential danger in cryogenic storage of large scale loss of material due to possible serious accidents. This could be as a result of human error, power failure, loss of liquid nitrogen, fire, flood, storm, earthquake or war. Such risks can be reduced by keeping duplicate stores in different regions but this still remains a serious concern. Cryogenically preserved populations are not able to adapt through gradual selection, to changes in the climate or disease background of the local or global environment. Finally, it is said that *in-vitro* storage through cryoconservation is possible for many, but not all, of the important animal livestock species in the long run.

Growing recognition of the roles and values of AnGRs over the past couple of decades has led to the initiation of conservation efforts. Many countries have attempted, or are attempting, to conserve some of their most important breeds using both *in-vivo* and *in-vitro* conservation methods. Nevertheless, conservation efforts for AnGRs lag far behind conservation efforts for plant genetic resources (FAO, 2000, p. 24).

2.2. Economic evaluation of AnGRs

This section revises background and definitions on the broad topic of environmental evaluation in an **economical way** (i.e. value is seen as an equivalent in money, compared to ecological value that is often expressed as intrinsic value[9]) and aims to classify the values of AnGRs that might exist and that can be the scope for evaluation.

The use of AnGRs is characterised by a high degree of ‘non-rivalry’ and ‘non-excludability’ and hence fits the premise of a pure public good (Romano, 1999) whose evaluation techniques are gleaned from environmental evaluation techniques. However, AnGRs can only be conserved by maintaining particular animals containing desired genes for conservation. In the light of this study, AnGRs should be conserved by conserving Borana cattle that are the **private property** of local livestock-keepers on the Borana plateau in northern Kenya and southern Ethiopia. Cattle, unlike AnGRs *per se* can be assigned to **common resources** (=rival in its use but not excludable). Due to the communal use of grazing areas on the Borana plateau it is not feasible to exclude others from benefiting from the genetic resource of Borana animals.

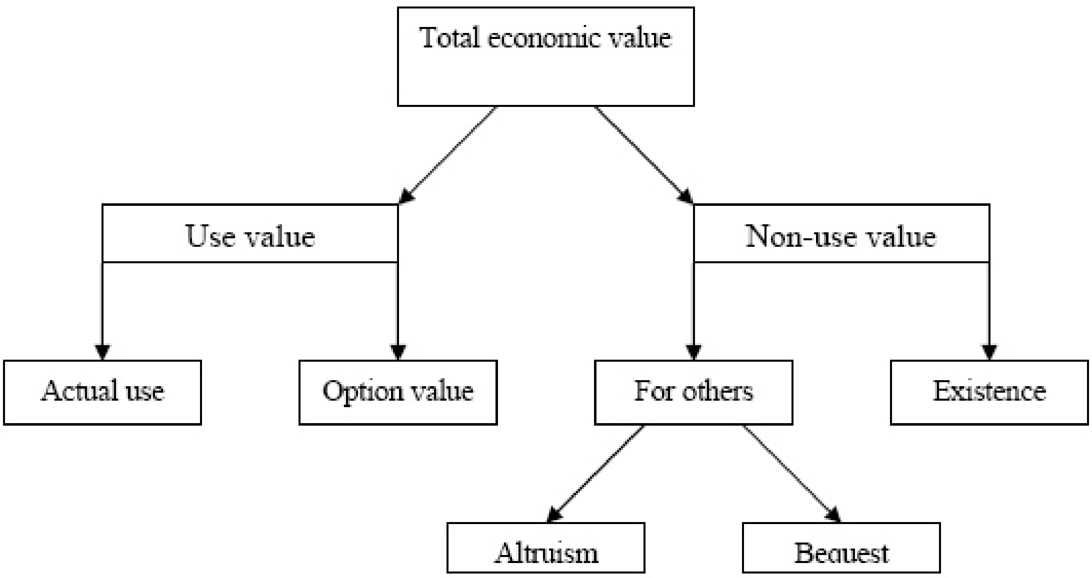
[9] Intrinsic value constitutes an environmental good’s or service’s value that is not derived from its utility but that is valuable ‘in’ and ‘for’ itself. In contrast, something has instrumental value if it is valued as a means to some other purpose, i.e. its value lies in the contribution to some other goal (Freeman, 2003, p. 6).

2.2.1. The total economic value of cattle

Bearing in mind that it is not the AnGR as a public good *per se* that should be conserved but **cattle**, the economic evaluation should focus on the values cattle might have in their private function to local livestock-keepers who bear benefits or detriments from their use.

The total economic value (**TEV)** concept is an important component of economic valuation (Pearce et al., 2002). The **net sum** of all the relevant values of WTP and willingness to accept (WTA) defines the TEV as any **change in well-being** due to a policy or project. A classification of TEV is depicted in Figure 1. The concept of WTP and WTA as indicators for a change in the TEV are essential in light of this study and the question of the most appropriate indicator will be detailed in Chapter 2.3.

Figure 1: Total economic value of cattle (source: Bateman et al., 2003, Chapter 1.7)



TEV is usually divided into **use** and **non-use** (or passive use) **values**. Use values relate to actual use of the goods in question (e.g. in terms of cattle such as milk yield or manure use), planned use or possible use in the future. Due to the already mentioned link between AnGRs as a public good and the private character of cattle containing the genetic resources, the use-values have a great relevance for the evaluation of cattle. Cattle breeds, like the Borana, should be conserved community-based and therefore the **internal** rather than the external[10] **effects** are of high importance. The types of non-use value can be manifold but are conveniently classified into existence value, altruistic value, and bequest value (see Bateman

[10] Positive externalities might, for instance, occur from the future use of genetic material and the insurance function of a conserved gene-pool for breeders and scientists world-wide.

et al., 2003, Chapter 7; OECD, 2002, Chapter 6.3). Non-use values of cattle can be derived by simply knowing and enjoying the existence of a particular breed.

Different techniques, as explained in the subsequent chapter, will be applied for only eliciting internal use-values of Boran cattle and for eliciting the entire TEV of cattle.

2.2.2. Economic valuation techniques

According to OECD (2002, Chapter 7) the available tools for evaluating the TEV by eliciting prices of multi-attributed public and environmental goods can be roughly divided into two classes: **stated preference method** and **revealed preference method**.

In principle, defining the appropriate method for measuring values depends on the **source of the data** (Mitchell and Carson, 1989, pp. 74-87). In case of **revealed preference methods**, the data is derived from observations of individuals acting in **real-world settings** where they also bear the consequences of their choices. In stated preference methods individuals respond to **hypothetical** questions (Freeman, 2003, p. 23). Revealed preference methods are further based on actual behaviour reflecting utility maximisation subject to constraints. They use **market prices** which in some way reflect the value of the public good but where prices are 'revealed' in some other commodity markets. Because of the fact that most of the environmental and public goods are not traded in the market, and hence do not have an offering price, as it is the case of AnGRs and some types of the Borana breed, the value of the good must be inferred through the application of models that reflect the relationship between market commodities and the environmental/public goods (Freeman, 2003, Chapter 1). To this category of methods belong hedonic pricing methods (HP), travel cost demand models (TCM) and household production models.

In this study, due to **market failures** as consequences to the existence of externalities and the common-resource character of cattle, the evaluation of the TEV of the Borana cattle is merely derived from **stated preference methods**. Reasons for market failure in the research area lie, for instance, in the use of middle-men and the oligopolistic behaviour by such intermediaries, and in the low trading volumes and poor information regarding prices in other markets. Other causes for market failure lie in the extreme poverty, asymmetric and imperfect information, and simple non-availability of pure Borana cattle and some of its types on the markets. Single functions (e.g. traction power), outputs (e.g. manure, milk for self-sufficiency) and services (e.g. dowry, status of wealth) that come along with the keeping of cattle are also not traded in the markets. The Ethiopian and Kenyan governments do not carry out actions that alleviate the market situations, such as providing the required infrastructure to open up markets[11] which would enable the livestock-keepers to sell their animals at better prices as an incentive for conservation. The link between lowland (where the Borana cattle originate from) livestock production and markets from the highlands which have wealthier populations is very poor or even completely absent (Reda, 2001). This leaves prices at existing local markets ranging at the lowest end. These market failures lead to **underestimated values** of Borana genetic material; applying a CE aims to find the "real" or "fair" value of Borana breeds and of their genetic material. This genetic material has great value particularly with regard to **unique traits** for which the Borana breed is known (e.g. the tolerance of ticks and of water shortage, the exceptional body size and horn appearance). The market price does not do justice to unique traits.

Stated preference methods draw their data from individuals' responses to hypothetical settings such as hypothetically created markets (Freeman, 2003, Chapter 6) where WTP estimates are, for instance, derived from questionnaires. The two most common forms of these models[12] are the **contingent valuation** (CV), on the one hand, in which respondents express directly their WTP and thus the value they place on one good/service and **CE**[13] or **choice ranking** (CR[14]), on the other hand. In CE cases, respondents are given a set of hypothetical alternatives, each depicting a different situation with respect to some environmental or public good with its attributes and are asked to select (CE) or to rank (CR) the alternatives according to their preference. People are asked to make trade-offs among different alternatives, from which their WTP can be statistically inferred (Smale et al., 2002).

Due to the private aspects of cattle and the importance of cattle to the local livestock-keepers, the CE will only focus on the **use-values** of the TEV of cattle (see Figure 1). Only values for certain attributes, as presented in the CE, will be evaluated, from the perspective of the utility

[11] However, the opening up of markets has to be treated cautiously as Alemayehu and Drucker (2002) argue that the genetic erosion of Borana cattle could also be triggered by the improvement of access to markets, as livestock-keepers will then be able to substitute the Borana with other higher output breeds.

[12] There are two other approaches in stated preference theory, namely the **conjoint analysis** in which respondents are asked to rate a set of bundles on some scale and **contingent activity/behaviour**. In the latter approach respondents are asked how they would change the level of some activity in response to the change in an environmental or public good (Freeman, 2003, Chapter 6). Conjoint and contingent activity/behaviour are not the scope of this study and hence not described in more detail.

[13] CE are also referred to as choice modelling and attribute-based approach (see Freeman, 2003, p. 161).

[14] CR belongs to the broad category of CEs. The economic framework and the experimental set up are the same for both approaches and hence when referring to the term CE throughout this study, that includes CR. The two approaches only differ in the data input and the number of choices one can generate with a given number of choice sets and respondents. This special case is detailed in Chapter 2.4.1.1.

they generate for local livestock-keepers. The CVM, on the other hand, enables the evaluation of the entire TEV of cattle. Respondents only state one value for cattle and the researcher does not know how much value of this value is due to use-values and how much non-use values respondents place on the good.

Most CE studies that have been conducted so far aiming to evaluate AnGRs by using CEs focus on single animal species. There has been a special issue in the “Ecological Economics” series unexceptionally dealing with the valuation of AnGRs (Ecological Economics Vol. 45(3), July 2003). The two publications that are most important for this study are both included in this special issue and are by Scarpa et al. One paper (Scarpa et al., 2003a) provides a practical approach where CE was employed in the case of Box Keken Creole pig in Mexico. The authors find that farmers care about weight increase, feed costs, disease resistance, and bathing frequency when choosing pigs in Mexico. In another paper by the same author (Scarpa et al., 2003b) the results of a CE, aiming to value cattle breeds in Kenya, are compared with those derived from a revealed preference method (in this case an hedonic analysis of market transaction data for cattle in Kenya) and conclude that both approaches provide similar results. Using both approaches, the authors found that Kenyan farmers valued weight, condition, some breeds, and sex. Tano et al. (2003), whose paper can also be found in the special issue on AnGRs, use conjoint analysis to measure the value of cattle traits in West Africa. The authors reveal fitness for traction, disease resistance, and reproductive performance to be the most important traits. Weight gain and milk yield are also important characteristics but less valuable than the others listed above. Jabbar and Diedhiou (2003) also identify milk yield, disease resistance, animal size, handling ease, market value, and ease of grazing as important attributes in livestock owner’s minds. The authors applied a preference rating approach in which a response variable is measured on an ordinal scale, showing the strength of preference for cattle breeds.

Other studies applying CE for evaluating AnGRs put emphasis on single wild animal species aiming to justify conservation for wild threatened animals (see e.g. White et al., 1997). Besides the evaluation of single animals species, much could be learned from this study through CEs applied to the evaluation of complex ecosystems such as, just to name a few, biodiversity (see e.g. Nunes and van den Bergh, 2001; Pearce, 2001 or Birol and Gyovai, 2003), habits and its conservation (see e.g. Christie et al., 2004), tropical forest (see e.g. Rolfe et al, 2000) or natural sites for recreation use (see e.g. Train, 1998; Hanley et al., 2001; Horne et al., 2005 or Scarpa and Thiene, 2005).

The main difference Between CE and CV is that while CV exercises pose a **single valuation** task and thereby only assesses the **overall** value (the TEV) of a good, CE studies comprise **multiple choices**, i.e. CE models are based on the **attribute** theory of value and are disaggregated into a number of values (Hanley et al., 1998a; Bateman et al., 2004). It is difficult to distinguish the value of each characteristic of a multi-attribute good when applying contingent valuation methods (CVM)[15]. CE is hence preferable in measuring the marginal value of changes in the characteristics of environmental and public goods (Bateman et al., 2003). This is often a more useful focus from a management/policy perspective than focussing on either the gain or loss of the good, or on a discrete change in its attributes. CE designs can avoid **multi-collinearity** problems that often arise in revealed preference analyses based on variations in actual attribute values across goods (Bateman et al., 2003). That is because in CE designs, in contrast to CVM designs, attribute levels are designed as orthogonal (see Chapter 4 on experimental design). CE may also avoid some of the **response difficulties** in CVM. For example, dichotomous choice designs in CVM may be subject to ‘yes-saying’ despite improvements in design standards (Adamowicz, 1995; Blamey et al, 1999). In a CE the experimental set up is generated in such a way that respondents do not make direct statements about the amount of money they would be willing to pay or to accept for a certain commodity. Instead, their WTP is revealed **indirectly** according to the choices they made motivated by their preferences.

Another benefit of the CE approach over CV is that CE provides the decision maker with greater **information** concerning preferences for a wide range of provision permutations (Bateman et al., 2004). Use of WTP over WTA is thought to reduce what is termed “**hypothetical bias”,** this refers to the problem of eliciting true preferences and accurate predictors of behaviour when there is no commitment on the part of the respondent to actually act on their stated preference (Pearce and Moran, 1994).

However, there are also some drawbacks in the application of CE. First of all, there may be **additional attributes** of the good not included in the design which generate utility[16]. Second, it is questionable that the value of the “whole” is indeed **additive**. Elsewhere in economics, objections have been raised about the assumption that the value of the whole is indeed equal to the sum of its parts. In order to test whether this is a valid objection in the case of CE, we

[15] CVM has been applied extensively in valuing ecosystems/landscapes such as freshwater, forest, habits etc (see e.g. Macmillan et al., 1996 or Spash, 2002) and to some extent endangered animal species (see e.g. Bateman et al., 1992; Boman and Bostedt, 1995 or Cicia et al., 2003).

[16] In practice, these are then captured in the constant terms in the estimated model.

need to be able to compare "whole" values from CE with values obtained for the same resource using some other technique (such as CVM or revealed preference methods) (Bateman et al., 2003). That comparison will be also a small part in this study, looking at the values of WTA compensation derived from CV, on the one hand, and WTP values derived from the CE, on the other hand.

Furthermore, the results from CEs are **sensitive to study design**. For example, the choice of attributes, the levels chosen to represent them, and the way in which choices are relayed to respondents (e.g. type of visible aid, explanation, the quality of enumerators etc.) may all impact on the values of estimates of consumers' surplus and marginal utilities. In particular, conducting a CE with individuals in rural areas in developing countries relies heavily on the quality of amplifying the experiment procedure to respondents who are mainly illiterate. Appropriate visible aid and skilled enumerators are therefore vital.

A further disadvantage of CE over CV is that the **complexity** of choices/ranks can be a problem for the respondents (Bateman et al., 2003) eventually leading to increased random errors (Mazotta and Opaluch, 1995). Bradley and Daly (1994) have found that respondents become fatigued, the more choices they are presented with. Ben-Akiva et al (1991) and Foster and Mourato (2003) found evidence of inconsistent responses that increase as the number of rankings increase. This implies that, whilst the researcher might want to include many attributes, and also **interactions** between these attributes, unless very large samples are collected, respondents will be faced with daunting choice tasks. This may lead them into relying on short-cuts to provide answers, rather than solving the underlying utility-maximisation problem (Bateman et al., 2003).

2.3. Welfare measure for cattle evaluation

For policy analysis, the researcher is often interested in measuring the change in quality of a good that is associated with a particular policy. For instance, a change in the attributes of cattle or the change of keeping one breed or the other can have an impact on livestock-keepers' welfare that is important to assess. Deprivation of the level of tick tolerance of cattle harms livestock-keepers in their income generation due to early death of animals or lower productivity. As a result, livestock-keepers are no longer able to keep this type of cattle and that leads to dwindling numbers of a certain breed and dwindling genetic resources as a biodiversity asset. Measuring this harm in monetary terms is a central element of setting up policy implications against the loss of genetic resources.

There most important welfare measure in this study is the c**ompensating surplus** (**COS).** It can be calculated by expressing indirect utility functions before and after a change in the good in question (e.g. the change from keeping Zebu cattle to keeping EB) (Rolfe et al., 2000; Bateman et al., 2003; Freeman, 2003). The subsequent two sections will detail the relevant formulas for calculating the COS in stated preference approaches.

2.3.1. Compensating surplus

There are two measures commonly applied for eliciting welfare indicators for changes in environmental or public goods (i.e. not only of attributes of goods but of whole **bundle** of goods) **compensating variation (COV)**, and **COS** (Freeman, 2003). Both measures of welfare change are theoretical refinements of the ordinary **consumer's surplus (CS)** (Hicks, 1943). CS is the difference between what the consumers are willing to pay and what they actually pay (Varian, 2003, Chapter 14). The CS is only an approximate measure and then measures the area under a Marshallian ordinary demand curve[17] but above the horizontal price line (Freeman, 2003, p. 49). The CS cannot be applied with regard to the underlying utility function (Freeman, 2003) and hence COV and COS are the appropriate measures. Besides these two measures there are equivalent surplus (EV)[18] and equivalent surplus (ES)[19]. In any case, the calculation of equivalent measures is not applied in this study and its detailed explanations is thus beyond the scope of this work. The most important tool with regard to this study is the COS.

The key aspect in which the four measures differ is not the direction of change in the level of the environmental good or service, but rather whether the individual is evaluating the change from the original level of utility and the new level of service (compensating surplus), or the new level of utility and the original level of service (equivalent surplus).

COS can be interpreted as the consumer's maximum WTP in order to gain a quantity or quality increase and still maintain her/his level of utility, or as the minimum level of compensation the individual is willing to accept for obtaining the decreased quantity/quality of a good. According to Freeman (2003, p. 55) COS asks what compensating payment will

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[17] The Marshallian demand curve is given by $x_i = x_i(P, M)$, i.e. the demand for quantity xi is a function of a vector of prices P and money income M (Hanley and Spash, 1993, p. 27).

[18] EV assesses what change in consumer's income (given the original price of the initial good) would lead to the same utility change as the change in the price of this good (Freeman, 2003, p. 51).

[19] ES asks what change in income is required (given the old prices and consumption levels of the initial good) to make the consumer as well of as he/she would be with the new quality of the good (Freeman, 2003, p. 51). The new situation will bring consumer to a new utility level in case a quality/quantity change in the good does or does not occur.

make the consumer **indifferent** to the original situation and the opportunity to purchase the new quantity/quality of a good. The **utility** is thereby kept **constant** at original level, both for the initial situation and the new situation in which a change in an environmental good has occurred. COS is closely related to COV; the only difference is that in case of COS the consumer is not allowed to adjust the purchase of the initial good in response to the compensating change in income (Freeman, 2003, p. 55). COS has become popular as a means of measuring welfare in stated preference method studies, and it is estimated from basic MNL models through the use of the following formula (Haab and Hicks, 1997; Rolfe et al., 2000; Freeman, 2003; Christie et al., 2004):

$$COS_n = -\frac{1}{\alpha_n}\left[In\left(\sum_i \exp(V_{i0})\right) - In\left(\sum_i \exp(iV_1)\right)\right] \tag{1}$$

Where COS_n is the COS welfare measure for individual n, α_n is the marginal utility of income, and V_{i0} and V_{i1} represent indirect utility functions before and after the change under consideration. Note that the argument in parentheses in this expression is the denominator of the logit choice probability in Equation (7). Aside from the division, expected CS in a logit model is simply the log of the denominator of the choice probability. It is often called **the log-sum term** (Train, 2003). V_{i0} is given by the inclusive value (IV) of the status quo situation (the breed that respondents are currently keeping) and V_{i1} is the IV after some policy (such as exchange of breeds). α_n is assumed to be a constant, and hence the expected loss or gain per animal can be measured and expressed as COS.

2.3.2. WTP and WTA compensation for conserving AnGRs

The mechanism of assessing the WTP or WTA compensation is a crucial tool for expressing measurers based on **substitutability**[20] (Freeman, 2003). In choosing between WTP and WTA approaches, it should be noted that large differences between such approaches have systematically been found in empirical studies, both in laboratory and field experiments, with WTA consistently exceeding WTP by as much as an order of magnitude (Bateman et al., 2003). WTA is, in contrast with WTP, unconstrained by **income** (income effect) and therefore usually greater than WTP (Bateman et al., 2003). One reason for that was suggested by

[20] By substitutability, economists refer to the quantity of one element in an individual's bundle of goods that is required to be increased in order not to leave the individual worse-off if the other element of the bundle is reduced. The trade-offs that individuals make as they choose less of one good and substitute more of some other good reveal something about the values they place on these goods (Freeman, 2003).

Carson (1991) who stated that WTA compensation questions are not **incentive-compatible** and that respondents have no experience with the question format and are thus giving the highest amounts that they think could be extracted in compensation rather than the minimum compensation that they would require. According to Hanemann (1991), even the true values may differ considerably as theoretically explained disparity is due to income effects as well as to substitution effects according to respondents' preferences and esteem for a particular good. Hanemann (1991) showed that the theoretical difference between WTP and WTA measures is larger for goods with low elasticities of substitution between the good in question and market goods. Traditional economic assumptions further imply that there should be little disparity between an individual's maximum WTP to acquire a good and the minimum compensation to relinquish the good WTA, when **income effects** are small (Hanemann, 1991) as they are with regards to cattle production in marginal East African regions.

However, recent experimental results suggest that the disparity persists for a wide variety of goods, even those with close substitutes (Horowitz and McConnell, 2002) and most research indicates that WTA is significantly larger than WTP (see Hanemann, 1991). One theoretical explanation for this large WTA/WTP ratio stems from **psychology** literature explained by the so called **endowment effect**. This effect suggests that **ownership** itself makes a good more valuable so that WTA exceeds WTP (Thaler, 1980). That holds true for cattle in East Africa and according to this explanation, they should be valued more because they are owned and livestock-keepers are subject to loss aversion and "a person who is loss averse suffers more from a loss than benefits from a gain of equal magnitude" (Kahneman and Tversky, 1979).

A CVM is applied in this study to derive a value for substituting certain breeds by the Ethiopian Borana (EB) cattle for the purpose of conservation, i.e. the CVM seeks to quantify the WTA compensation for maintaining the EB breed. It was decided on a WTA approach for the CV set up (see Chapter 6.4) because the **property rights**[21] of cattle reside with the local livestock-keepers and as long as the **income** of many respondents is quasi inexistent, to ask for WTP is not appropriate. As these WTA values were treated as costs to livestock-keepers for a change in quality, the CV setting was conducted in such a way, that livestock-keepers were only able to state either positive WTA values or a WTA of zero. No negative WTA values were allowed in the chosen setting (see Chapter 6.4 for more details).

[21] The choice between WTP and WTA as the appropriate welfare measure depends partly on the property rights structure and on the type of change from the status quo position (Smale et al., 2002; Bateman et al., 2003; Freeman, 2003). If the respondents do not have the right to the resource, they are asked their WTP to have it; if they own the resource already, they're asked their WTA compensation for giving it up. Here, the property rights of cattle reside with the livestock-keepers.

2.4. Choice model specifications

This section elaborates on the theoretical framework of two choice models that are applied in this study: the basic MNL model and a generalised form of it, the MXL model.

2.4.1. The basic multinomial logit model

Unlike other stated preference methods, such as CVM, the CE and CR enable estimation of not only the value of the public good as a whole (i.e. the value of the cattle *per se*), but also the implicit marginal values of its attributes (Hanley et al., 1998a; Bateman et al., 2003). Both methods are grounded on Lancaster's theory of consumer choice (Lancaster, 1966), stating that consumers derive utility not from the good *per se* but from the bundle of attributes and magnitude (levels) of the attributes they provide. The methods are further based on the random utility theory (RUM) (McFadden, 1974), which illustrate that utility for a consumer derived from a good consists of two decomposed parts: an observable and deterministic part and an unobservable part. The RUM is based on the composite utility function as follows:

$$U_{nj} = V_{nj}(X_{nj}) + \varepsilon_{nj} \qquad (2)$$

Where U_{nj} is the total utility that individual n obtains from choosing the alternative j from a finite set *C*. The observable part V_{nj}, is a function of a vector, X_{nj}, consisting of choice-specific attributes as well as individual specific characteristics. Only the observed part V_{nj} is known by the analyst up to some parameters (Train, 2003). The unobservable part ε_{nj} describes other factors or attributes of a good apart from the stated attributes but which also influence the consumer's choice. ε_{nj} is treated by the analyst as random and its is assumed to be independent of X_{nj} and follows some predetermined distribution[22] (Train, 2003).

$V_{nj}(X_{nj})$ is also referred to as **indirect utility function**. A likelihood function is then derived as a function of the parameters of the indirect utility function. The method of maximum

[22] It is assumed that the random error terms are **independent and identical distributes** (iid) (Train, 2003), i.e. iid implies that the variances associated with the component of a random utility expression describing each alternative (capturing all unobserved influences on the choice) are identical, and that these unobserved effects are not correlated between all pairs of alternatives (Louviere et al., 2000). According to Train (2003) the key assumption lies in the independence of the error terms, i.e. that the unobserved portion of utility for one alternative is unrelated to the unobserved portion of utility for another alternative. Under independence, the error for one alternative provides no information to the researcher about the error for another alternative. Stated equivalently, the analyst has specified V_{nj} sufficiently that the remaining, unobserved portion of utility is essentially "white noise." In case these logit assumptions are violated one option is to use a different model, such as a mixed logit or a latent class model.

likelihood estimation (MLE) is most commonly used to estimate RUMs and to find the coefficients of the indirect utility function which maximise the probability that a given respondent ranks the alternatives in the order they were actually selected. That means the coefficients show the relationship between the probabilities of selecting one option with its attributes that are most likely to occur given the choices the respondents are facing and eventually making (Sandefur et al., 1996).

Option i will be chosen over option j if:

$$V_{ni}(X_{ni}) + \varepsilon_{ni} > V_{nj}(X_{nj}) + \varepsilon_{nj}; \forall\ i \neq j, \forall\ \mathrm{j} \in C. \tag{3}$$

The probability that individual n will choose option i over option j will then be given by:

$$\Pr ob\ (i/C) = \Pr ob\{V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}\}, \forall\ i \neq j, \forall\ \mathrm{j} \in C \tag{4}$$

C is the complete finite set of options/alternatives. The estimation of Equation (4) can conveniently be done when assuming a **Gumbel**[23] distribution (McFadden, 1974). By further assuming a **linear functional form** for $V_{nj}(X_{nj})$ (the indirect utility function) and the predetermined iid distribution (see Footnote 21) for the error components in Equation (4) a discrete choice model, known as MNL model[24] (McFadden, 1974) can be constructed:

$$\Pr ob_{ni}(j/C) = \frac{\exp(\mu\beta' x_{ni})}{\sum_{J} \exp(\mu\beta' x_{nj})} \tag{5}$$

X is a vector of independent variables upon which utility is assumed to depend, and β is a vector of parameters to be estimated, and $\Pr ob_{ni}$ gives then the probability of choosing alternative i out of j alternatives (from the total finite set C) for decision maker n (Bateman et al., 2003). The **scale vector** μ is usually assumed to equal 1 (implying constant error variance) so that the model becomes deterministic and the $\beta' s$ can be identified (Hanley et al., 1998b). It is noteworthy that McFadden (1974) demonstrated that the log-likelihood

[23] The Gumbel distribution for the errors term has been referred to by a number of other names, including "extreme value type I distribution", "Weibull distribution" or "double exponential distribution" (Louviere et al., 2000, p. 45). However, in all cases it implies that the probability of any particular alternative being chosen as the most preferred can be expressed in terms of the logistic distribution, which finally results in the MNL model specification (Greene, 2003a, p. 720).

[24] In this study, the dependent variable takes four values (animal A, animal B, animal C, no animal), and hence a MNL model is required (Bateman et al., 2003). If the dependent variable only takes on two values (e.g. A or B) it is a binary logit model (Greene, 2003a, p. 665). MNL models are applied when there is a single decision among two ore more alternatives (Bateman et al., 2003).

function with these choice probabilities is globally concave in β parameters which helps in the numerical maximization procedures (Train, 2003). The basic MNL model is therefore given by:

$$\Pr ob_{ni}(j/C) = \frac{\exp(\beta' x_{ni})}{\sum_{J} \exp(\beta' x_{nj})} \qquad (6)$$

The logit probabilities are known for two main desirable properties. First of all, $\Pr ob_{ni}$ is necessarily between zero and one, as required for a probability. When V_{ni} rises, reflecting an improvement in the observed attributes of the alternative, with V_{nij} (taken that $i \neq j$) held constant, $\Pr ob_{ni}$ increases. $\Pr ob_{ni}$ decreases when V_{ni} decreases, since the exponential in the numerator of Equation (6) approaches zero as V_{ni} approaches $-\infty$. The logit probability for an alternative is never exactly zero. If the analyst believes that an alternative has actually no chance of being chosen by a decision maker, that alternative can be excluded from the choice set (Train, 2003). A probability of exactly 1 is obtained only if the choice set consists of a single alternative. The second desirable property is that the choice probabilities for all alternatives sum up to one, i.e. decision makers necessarily choose one of the alternatives. The denominator in Equation (6) is simply the sum of the numerator over all alternatives, which gives this summing-up property automatically (Train, 2003). With logit models (as well as e.g. with nested logit models and MXL models), interpretation of the choice probabilities is facilitated by recognition that the denominator serves to assure that the probabilities sum to one. The MNL is an extension of the logit model and is applied when the choice is between more than two[25] alternatives, as it is the case for the setting of this study.

2.4.1.1. Special case of choice ranking

Instead of just choosing one alternative the experimental setting in this study uses ranked data, i.e. respondents are asked to rank the alternatives. The way this ranking is requested in this study is as follows: the respondent is asked to choose the "best" alternative and then, after having made this choice, they are asked which of the remaining alternatives they would choose, continuing through all the alternatives presented in the choice set. Ranked data can be treated without any modification in basic MNL models and MXL models (Train, 2003, p. 160). However, the model specification slightly differs as explained as follows: based on the basic MNL model, the probability of any ranking of the alternatives from best to worst can be

[25] For two alternatives it would be a binary logit model.

expressed as the product of logit formulas. Here, a livestock-keeper was presented with four alternatives labeled animal A, animal B, animal C, and “no animal” (D). Let us suppose the livestock-keepers ranked the alternatives as follows: C, B, D, A, where C is the first choice. If the utility of each alternative is distributed iid extreme value (as for a logit model), then the probability of this ranking can be expressed as the logit probability of choosing alternative C from the set A, B, C, D, times the logit probability of choosing alternative B from the remaining alternatives A, B, D, times the probability of choosing alternative D from the remaining alternatives A and D (Train, 2003, p. 161). This can be expressed as follows:

$$\Pr ob_n(C,B,D,A) = \frac{\exp(\beta' x_{nC})}{\sum_{J=A,B,C,D} \exp(\beta' x_{nj})} \frac{\exp(\beta' x_{nB})}{\sum_{J=A,B,D} \exp(\beta' x_{nj})} \frac{\exp(\beta' x_{nD})}{\sum_{J=A,D} \exp(\beta' x_{nj})} \quad (7)$$

This equation implies that the ranking of the four alternatives can be represented as being the same as three independent choices by the respondent. These three choices are called **pseudo-observations**, because each respondent’s complete ranking, which constitutes an observation, is written as if it were multiple observations. In general, a ranking of J alternatives brings about $J-1$ pseudo-observations. For the first pseudo-observation, all alternatives are considered available, and the dependent variable identifies the first-ranked alternative. For the second pseudo-observation, the first-ranked alternative is discarded. The remaining alternatives constitute the choice set, and the dependent variable identifies the second-ranked alternative, and so on. In creating the input file for logit estimation, the explanatory variables for each alternative are repeated $J-1$ times, making that many pseudo-observations.

Once the data are constructed in this way, the logit estimation proceeds as usual. A logit model on ranked alternatives is often called an **exploded logit**, since each observation is segmented into several pseudo-observations for the purposes of estimation (Train, 2003, Chapter 10).

2.4.1.2. *MNL model violations and validity*

The logit model implies a certain pattern of substitution across alternatives, known by the property of **Independence from Irrelevant Alternatives**[26] **(IIA)** (Greene, 2003a, p. 724). While the IIA property is realistic in some choice situations, it is clearly inappropriate in others, as first pointed out by Chipman (1960) and Debreu (1960). The IIA axiom states that the ratio of the probabilities of choosing one alternative over another is unaffected by the presence or absence of and additional alternatives in the choice set (Louviere et al., 2000). Hausman and Mc Fadden (1984) developed a test that can be applied to detect IIA violations. This test basically involves constructing a likelihood ratio test around different versions of the model where choice alternatives are excluded. If IIA holds, then the model estimated on all choices (the full choice set) should be the same as that estimated for a sub-set of alternatives, i.e. if a subset (here: animal profile) of the choice set is indeed irrelevant, omitting it from the model altogether will not significantly change the parameter estimation. A test of the hypothesis that the parameters on the subset are the same as the parameters on the full set constitutes a test of IIA. Hausman and McFadden (1984) provide an appropriate statistic for this type of test applicable on the results of the basic MNL model. The test statistic is given by:

$$\chi^2 = (\hat{\beta}_s - \hat{\beta}_f)'\left[\hat{v}_s - \hat{v}_f\right]^{-1}(\hat{\beta}_s - \hat{\beta}_f) \tag{8}$$

Where s indicates the estimators based on the restricted subset and f on the full (unrestricted) subset, and v_s and v_f constitute the respective estimates of the asymptotic covariance matrices (Kontoleon, 2003). The test statistic follows a χ^2 distribution with K degrees of freedom and K being the number of restrictions (Kontoleon, 2003).

2.4.1.3. *Goodness of fit and hypothesis testing*

A statistic called the **likelihood ratio test** is often used with discrete choice models to measure how well the models fit the data. Assuming the maximum likelihood has been used to estimate the utility in parameters of a basic MNL model, then this test reveals whether

[26] Consider the famous red-bus–blue-bus problem (Train, 2003). A traveller has a choice of going to work by car or taking a blue bus. For simplicity assume that the representative utility of the two modes are the same, such that the choice probabilities are equal, namely both equal to 0.5. The ratio of probabilities is one: now suppose that a red bus is introduced and that the traveller considers the red bus to be exactly like the blue bus. The probability that the traveller will take the red bus is therefore the same as for the blue bus, so that the ratio of their probabilities is one, i.e. the probability of all three means is one third. However, in the logit model the ratio of probabilities of taking a car to taking a bus should be the same, namely 0.5, whether or not another alternative, in this case the red bus, exists.

some particular subsets of variables have any significant contribution to the initial model (Louviere et al., 2000, p. 53). Therefore the null hypothesis to be tested is if subsets of the βs are significant, i.e. are non-zero. Broadly speaking, the null hypothesis specifies some sort of restriction on the β parameters. The likelihood ratio index is defined as (Louviere et al., 2000, p. 53; Greene, 2003a, p. 485):

$$LL^* = \frac{LL_R}{LL_U} \qquad (9)$$

Where LL^* is the likelihood ratio, LL_R is the maximum likelihood estimator in which M elements of the parameter space are constrained by the null hypothesis, i.e. with any kind of restriction and LL_U is the maximum likelihood without the constrains. LL^* can take on values between zero and one, with both likelihoods always being positive and with LL_R never being greater than LL_U (Greene, 2003a, p. 485).

$-2\ln LL^*$ is approximately χ^2 distributed with M degrees of freedom if the null hypothesis if true (Louviere et al., 2000, p. 53). After the calculation of LL^* one has to determine if the quantity $-2\ln LL^*$ is greater than the critical value of $\chi^2{}_M$ at an assumed significance level. If that is the case, the null hypothesis can be rejected (Greene, 2003a, p. 486), i.e. the initial model seems not to be the best model and the additional estimated parameters add to the predictive capability of the initial (base) model (Hensher et al., 2005, p. 330). If $-2\ln LL^*$ is less than the critical χ^2 value, the analyst cannot conclude that the specified model is better than the initial model, and hence the best estimate of utility is the average utility estimated from the initial model (Hensher et al., 2005, p. 331).

A so-called **likelihood ratio index** (ρ^2) can be constructed that can then be used to measure the **goodness-of-fit** of a MNL model (Louviere et al., 2000, p. 54). The statistic of ρ^2 is as follows (Louviere et al., 2000, p. 54):

$$p^2 = 1 - \frac{LL_R}{LL_U} \qquad (10)$$

The ρ^2 value in MNL models is similar to R^2 in conventional analysis, except that validity occurs at lower levels. Hensher and Johnson (1981) comment that values of ρ^2 between 0.2 and 0.4 are considered to be extremely good fits.

2.4.2. The mixed logit model

The MXL model is a modification of the basic MNL model featuring important aspects that the MNL cannot cope with. One great advantage of MXL over basic MNL is that MXL relaxes the assumption that the unobserved portions of the utility function are IID. The biggest benefit of applying MXL models is that it is able to detect consumer heterogeneity upon the choices for (or ranking of) alternatives. With relevance to this study, accounting for preference heterogeneity among livestock-keepers supports **policy decisions** for possible conservation initiatives. The aim is to understand who makes which choice and how different types or segments of individuals are affected by their choice making. That eventually permits targeting of those livestock-keepers who are most "willing" and most suitable for participating in an *in-situ* conservation programme for the pure Borana.

Recent applications of MXL models[27] have shown that they **out perform** conditional logit approaches both in terms of overall fit as well as in the accuracy of their **welfare measure** estimates (e.g. Kontoleon et al., 2002; Scarpa and Del Giudice, 2004) although some have cautioned that while the MXL models explicitly account for preference heterogeneity, they are not well-suited for explaining the **sources of heterogeneity** (e.g. Boxall and Adamowicz, 1999). The paper by Train (1998) and a book by the same author (2003) were taken as a guideline for the use of MXL models as he did pioneer work with respect to MXL models and consumer taste heterogeneity.

The MXL allows all choice-specific parameters to **vary randomly** across individuals, i.e. it allows that the $\beta's$ as well as the errors term are not the same for all individuals. The MXL probability can be derived from utility-maximizing behaviour in several ways that are formally equivalent but provide different interpretations. Two ways are widely accepted throughout literature on environmental evaluations. The two approaches are, firstly, variation in the **error term** and secondly variation based on **random coefficients** (Train, 2003, Chapter 10). The most straightforward derivation, and most widely used in recent applications is the latter approach (Train, 2003) and it has also been applied in this study and its specification is issued as follows.

The specification for the random coefficient derivation is the same as for the basic MNL except that β varies over decision makers rather than being fixed. Hence, following the specification as stated in Equation (6), the specification of the MXL model will be described

[27] MXL models are often also termed Random Parameter Logit (RPL) models.

in this section. The decision maker faces a choice among J alternatives. The utility of person n from alternative j is specified as follows:

$$U_{nj} = \beta_n X_{nj} + \varepsilon_{nj} \tag{11}$$

Where X_{nj} are observed variables that relate to the alternative and 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 among decision makers in the population with **density** *f (β).* This density is a function of parameters θ that are n**ormally**[28] distributed with a **mean** b and **covariance** W of the $\beta's$ in the population. Then $\varphi(\beta / b, W)$ is the normal density with mean b and covariance W, whereby b and W have to be estimated. The analyst can freely choose the distribution for the coefficients and estimates the parameters of that distribution. The distribution can be specified to be normal or lognormal, or triangular or uniform. The lognormal distribution is useful when the coefficient is known to have the same sign for every decision maker, such as a price coefficient that is known to be negative for everyone (Train, 2003). The MXL is a weighted average of the logit formula of Equation (6) at different values of β, with the weights given by the density $f(\beta)$ (Train, 2003). The underlying density is called the mixing distribution. The basic MNL model is hence a special case where the mixing distribution $f(\beta)$ is 1 for $\beta = b$ and 0 for $\beta \neq b$ (Train, 2003). In this study $f(\beta)$ is assumed to be continuous with a distribution specified to be **normal** for all parameters that vary randomly across individuals. Hence, b and W are sought to be estimated.

The analyst does not know β_n and therefore cannot condition on β (Train, 2003). The unconditional choice probability is therefore the **integral** of $L_{ni}(\beta_n)$ over all possible variables of β_n. If utility is linear in β , then the choice probability under a **normal density** is the MXL probability as follows:

$$P_{ni} = \int \frac{\exp(\beta' x_{ni})}{\sum_j \exp(\beta' x_{nj})} \phi(\beta / b, W) \partial\beta \tag{12}$$

[28] The coefficients can take on any other distribution, such as lognormal, uniform, triangular (Train 2003, Chapter 6). The analyst can freely choose which. The lognormal distribution is useful when the coefficient is known to have the same sign for every decision maker, such as a price coefficient that is known to be negative for everyone (Train, 2003, Chapter 6). However in this study the normal distribution was chosen for all parameters that vary randomly across individuals.

Notice the parameters that describe the density of β as ϕ. The more appropriate way to denote this density is $f(\beta/\phi)$. The MXL choice probabilities do not depend on the values of β. These probabilities are $P_{ni} = \int L_{ni}(\beta) f(\beta) \partial\beta$, which are functions of ϕ and $L_{ni}(\beta)$ is the logit probability evaluated at parameter β (Train, 2003, Chapter 10).

Under some derivations of the MXL model, the values of β have interpretable meaning as representing the tastes of individual decision makers. In these cases, the researcher might want to obtain information about the $\beta's$ for each sampled decision maker, as well as the θ that describes the distribution of $\beta's$ across decision makers. This interpretation will be very useful when it comes to integrating socio-economic characteristics of livestock-keepers on their choice for cattle (see Chapter 5).

2.4.2.1. Panel data setting

MXL models are useful when considering models of **repeated choice** (=**panel data**) by the same decision maker (Brownstone et al., 2000). The case when choice sets between 4 and 32 are common (Train, 2003). The same draws of random parameter vectors are used for all choice sets (treating choice sets as independent). Applying the MXL model in the context of panel data is very important for this study because repeated choices by the same livestock-keepers shed light on their socio-economic characteristics (i.e. their heterogeneity) that eventually might lead to different taste preferences for cattle. Hence, the use of panel data will be issued in more detail at this point.

A series of presented choice sets to one respondent, with the attributes of the products varying so as to determine how the respondent's choice changes when the attributes change. The researcher therefore observes the sequence of choices by each respondent. Data that represent repeated choices like these are called panel data (Train, 2003). If the unobserved factors that affect decision makers are independent over the repeated choices, then logit can be used to examine panel data in the same way as purely cross-sectional data (Train, 2003). The MXL mode that is formed here is in terms of the likelihood function for a set of observations collected in a **panel data setting**. The panel data setting in this survey is that that each respondent made choices 3 (for bulls) or 4 (for cows) times and that is treated as panel.

As already indicated in Chapter 2.4.1.1, the data set in this study was motivated by full rankings made by livestock-keepers (see Equation (7)). A MXL model can be estimated on ranked data with the same explosion than the basic MNL model (Train, 2003, p. 162).

Assume now that β is random with density $g(\beta/\theta)$, where θ are parameters of this distribution. Using β as a condition, the probability of the person's ranking is a product of logits, as given in Equation (7). The unconditional probability is then the integral of this product over the density of β:

$$\Pr ob_n(C,B,D,A) = \int \left(\frac{\exp(\beta' x_{nC})}{\sum_{J=A,B,C,D} \exp(\beta' x_{nj})} \frac{\exp(\beta' x_{nB})}{\sum_{J=A,B,D} \exp(\beta' x_{nj})} \frac{\exp(\beta' x_{nD})}{\sum_{J=A,D} \exp(\beta' x_{nj})} \right) g(\beta/\theta)\partial\theta \tag{13}$$

The MXL model on ranked alternatives is estimated with regular MXL routines for panel data, using the input data setup as described previously for logit, where the $J-1$ pseudo-observations for each ranking are treated as $J-1$ choices in a panel. The MXL incorporates the fact that each respondent has his own coefficients and, importantly, that the respondent's coefficients affect his entire ranking, so that the pseudo-observations are correlated. A logit model on mixed data not using a full ranking approach does not allow for this correlation (Train, 2003, p. 162).

2.5. The contingent valuation method

The CVM will play a significant role in the costs assessment (Chapter 6) and its specification will only briefly be outlined at this point. The most commonly used CVM approach involves directly[29] asking respondents what value they place on a specific change in their environment/policy change of interest or the maximum amount they would be willing to pay to obtain this change (Freeman, 2003, p. 161). In this study, the change is given by a shift from somebody's cattle breed to the EB subtype; the CVM was designed in such a way that respondents were asked how much compensation they would require to change their herds to EB. The question was **open-ended**[30] and the livestock-keeper, rather than being offered a number by the enumerator, had to state a number. One benefit of open-ended questions is that

[29] CV is termed a **direct** approach within the stated preference methods to elicit WTP or WTA values while creating a hypothetical scenario of a market situation that facilitates the data collection. CE, on the other hand is considered an **indirect** approach.

[30] These questions can either be open-ended or respondents can be asked for a Yes or No answer (closed-ended formats or dichotomous choices). In the case of closed-ended questions, respondents are provided with a certain amount of payment or acceptance for a changing situation (a starting value) and asked whether they would pay/accept this amount. Questions of this type are referred to as discrete choice questions (Freeman, 2003, p. 162). Just as in the case of CE, it is the RUM which provides the basis for analysing the data obtained from such as discrete CVM. This utility-theoretic approach to calculate welfare measures from CV data was suggested by Hanemann (1984) but as it is not applicable to this study, it will not be discussed further in detail at this point.

the probability of anchoring bias is reduced (Bateman et al., 2003, Chapter 4), i.e. respondents are not provided with cues about what the value of changing to EB might be.

With this approach respondents directly express the monetary value, their minimum WTA, as a measure of welfare change (Freeman, 2003, p. 162; see also Chapter 2.3.3 of this study). It has to be stressed that prior to the CV exercise the assumption was made that livestock-keepers would face **less utility** in the new situation in which they would substitute their status quo breed by EB and were then asked how much money they need to be **indifferent** to this loss in utility. Respondents were not allowed to state a negative WTA (hence a WTP) in case that they would be better-off from the change to the EB than they were with their current breeds. If this case applied, it was simply assumed that respondents would have a WTA compensation of zero Euros. This is the reason why on average only a positive WTA can be obtained. This WTA value is overestimated because it does not include the "real" values of those livestock-keepers that would in theory be willing to pay for receiving the EB.

The **payment mechanism** of the hypothetical scenario is of crucial importance for the eliciting of accurate and reliable responses (Bateman et al., 2003, Chapter 4). Here, in the context of an open-ended approach, a **bidding game** was applied. Livestock-keepers were first asked to state their minimum WTA compensation for keeping EB cattle instead of their common breed. They were then stepwise asked whether they would also accept lower payments. In order to avoid large individual bids (outliers) that are obviously invalid (taking into account the low average income of livestock-keepers in the research area), an upper limit was set for the starting value of the open-ended question.

The open-ended responses were analysed by calculating the **sample mean** of the given sets of welfare measures that were produced for each respondent.

2.6. Summary

This chapter reviewed several advantages and disadvantages of conservation strategies and highlighted the *in-situ* conservation as current state-of-the-art strategy in preserving AnGRs. This strategy was found to be particularly relevant for application in developing countries where technologies und financial support are lacking. The chapter further reviewed stated preference methods as the preferred approach to assess the total economic value of genetic resources with regard to this study of the Borana breed and its genetic material. The main focus thereby was on the indirect eliciting of WTP estimates through the application of a CE. The main advantages of CE was argued to be the provision of the implicit marginal values of cattle attributes and not only of cattle *per se*. Against this background this chapter put considerable effort into the elucidation of the model specification upon which the entire CE is based, starting with Lancaster's theory of consumer choice, over the RUM, over McFadden's MNL model and ultimately bringing out the framework of the more complex MXL model. The CVM was also briefly detailed, emphasising that, compared to the CE, the CVM in this study made use of WTA values rather than WTP values. The chapter clarified that the CE method was chosen in order to elicit monetary values of cattle while the objective to use CVM is to assess costs. The chapter concluded with the appraisal of applicable welfare measurements, namely implicit prices for a change in single cattle attributes and COS for a change in entire cattle breeds.

CHAPTER THREE

Background on the Borana society, its land and genetic aspects of its cattle breed

3. Background on the Borana society, its land and genetic aspects of its cattle breed

Chapter 3 looks at the research area in detail, including geographical and socio-economic issues of the Borana societies, as well as genetic aspect of their cattle breed. This chapter further investigates the benefits of different Borana subtypes that are known in the research area and compares them according to their performance as it is perceived by local livestock-keepers. This chapter closes with information on country-specific threats to the survival of cattle and, especially, of the Borana breed. Identifying regional distinctions in these threats assist policy makers in deciding about conservation initiatives with particular regard to the question of “how” to conserve the pureness of the Borana breed.

3.1. Background on the research area

Ethiopia and Kenya are the two countries where this study has been conducted. This chapter reviews secondary information on geology and sociology of the Borana[31] land and culture in Ethiopia and Kenya. The research had been designed to be transboundary in order to cover neighbouring Kenya and Ethiopia for the purpose of comparing livestock-keepers' preferences for this indigenous breed in the two countries. This chapter provides an overview of the state of the Borana society in the research area and further seeks to clarify the meaning of breeds and how they are formed. Finally, against this background, the Borana breed and its benefits and potential threats will be elucidated.

3.1.1. The Borana plateau and its people in Ethiopia

Ethiopia consists of eleven administrative **states**: Tigray, Amhara, Afar, Benshangui, Addis Ababa, Dire Dawa, Somali, Harari, Oromiya, Southern and Gambela. Ethiopia has a total population size of 61,095,000 inhabitants and a population annual growth rate of 3.3 percent (1988-99) (FAO, 2004). The Borana zone is one of the 12 administrative **zones** (=*woreda*s) of Oromiya Regional State and is located in the far south of Ethiopia bordering Kenya.

The zone's 12 *woredas* are further divided into 448 **peasant associations** (PAs) as the lowest formal administrative structures. The Borana zone comprises 190 PAs (69 in the upland weredas). The total population of Ethiopia amounted to approximately 71 million inhabitants in 2003 (FAO, 2004). The most recent census in 2001 on the plateau recorded a total

[31] The name Borana means “free”, in reference to their nomadic nature, as opposed to the agricultural *Galla* (Fratkin and Roth, 2005).

population of 480,000 inhabitants, with an annual population growth rate estimated between 2.5 and 3 percent (Homann et al., 2003).

The Borana plateau or zone occupies a total land area of about 95,000 square kilometres with an altitude of 1,600 meters above sea level (ASL) in the northeast to about 1,000 meters ASL in the extreme south of Ethiopia (Kamara, 2000). Urban agglomerations can be found at Negelle, Yabello and Moyale towns, whereas the open grazing areas occupied by livestock-keepers have no permanent encampments. An important link to urban markets is the tarmac road from Addis Ababa to Nairobi which crosses the plateau.

The Borana plateau is divided into four ecological zones based on soil types, natural vegetation, primary productivity, and duration of growing seasons. These include the savannah in the north, which has the potential to carry relatively high numbers of livestock, the bush land with high shrub cover in the central zone, the medium-potential grassland in the east, and the volcanic areas in the west (Kamara, 2000). The climate on the Borana plateau is semi-arid, with average annual rainfall ranging between 350 mm and 900 mm.

3.1.1.1. The organizational structure of the Borana society

The Borana plateau is largely occupied by the **Oromo-Borana**[32] people. Other ethnic groups on the plateau living interspersed with the Borana include the **Guji**, the **Garri**, the **Konso,** the **Gabra** and the **Hamer**. The Borana have fought with all these groups except the Konso at various times in the past. **Clashes** with Guji arise over salt licks and are often settled fairly quickly by elders from both sides. Fierce fighting between the Borana and the Garri in 1991-92 and again in 1996 resulted in heavy losses on both sides. Territorial claims and **rights over resource** use has been the cause. Although most conflicts are settled quickly through government interference, the Borana zone is known for its ongoing ethnic tensions and its severe drought conditions (Coppock, 1994).

The Borana culture is also known for its traditional ***gada*** system, an indigenous and complex socio/political structure that governs the strategic interests of the Borana society. The *gada* system is believed to have evolved in the 1600s and it is based on a system that divides the Borana community into a number of **general classes (**Kamara, 2000). It is responsible for all issues affecting the pastoral life of the communities, including governance of pastures, provision of a framework for socio-political stability and protection from external invasions

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[32] Correctly the cultural group's name is termed Oromo-Borana but throughout this study it is simply referred to as Borana people. The Borana are part of a very large group of pastoral societies with about 4 to 5 million persons in total in Kenya and Ethiopia.

(Homann et al., 2003). A new *gada* is elected after every eight years by an assembly of all the Borana people or their representatives (**gumi gayu**). Since 1992 the two systems, the *gada* system and the administration system based on the PAs, have existed side by side on the Borana plateau (Helland, 2000).

Over 90 percent of the livestock-keepers' cash **income** is derived from livestock sales, as other alternatives for income generation are very few mainly due to the lack of infrastructure (Homann et al., 2003). The Borana people are **semi-sedentary pastoralists**, with cattle constituting the larger portion of the household herd. Lately, however, herd diversification to include more goats and camels is being pursued as an **insurance measure** to mitigate vulnerability to drought. This is a rational choice considering that close to 70 percent of the regional herd was lost during the 1991/92 drought alone. 80 percent of livestock was again lost during the drought 2005/06 (ILRI, 2006b).

Natural resources including pastures are largely **communal**, although individual crop cultivation and private enclosures appear to be increasing in recent decades (Kamara, 2004, p. 26). The Borana are also well known for having some of the finest **grazing** land in Africa and for housing well reputable cattle breeds with outstanding characteristics. Until a few decades ago, the southern Borana rangelands had in fact the reputation for being a model for traditional African pastoralism (Coppock, 1994). Traditionally, Borana livestock-keepers used to divide their pasture into *foora* and *warra*. *Foora* are satellite pastures that are used as temporary grazing camps for the mobile herds (non-breeding herds). In the **wet season**, the mobile herds graze in the *foora* pastures far away from the villages, exploiting the surface rainwater (Helland, 1980). During the **dry season** the mobile *foora*-herds return closer to the rangelands of the well complexes (Helland, 1980). That enables the *foora*-herds to reach the wells during the dry season and return back to *foora* pastures within 2 to 3 days (Hogg, 1990). *Warra* pastures are used all year by the milk herds. *Warra* is a family homestead, a residential grazing area for milk herds (Helland, 1980; Coppock, 1994; Huqqaa, 1998). Castrated bulls that are used for traction are also kept in *warra.* A third partition is known as *kalo*, a fenced forage bank for weak and sick animals that is installed within the villages (Huqqaa, 1998; Homanm et al., 2003).

3.1.1.2. The deep wells

A particular feature on the plateau is the **permanent supply** of water by **nine** deep well complexes and a number of dispersed springs. The deep wells (*tula* wells) are perhaps the most fundamental feature that has shaped the Borana society (Helland, 1980), constituting a vital source without which keeping cattle in the Borana ranges would be impossible in the dry season (Helland, 2000). *Tula* wells are old, usually much deeper than normal well complexes and require massive excavation with shafts sunk into rock. The *tula* wells comprise the most reliable source of water, never drying up even in the course of severe droughts (Coppock, 1994). The nine deep wells underlie a strong social organisation controlling construction, access, usage and maintenance of the wells (Helland, 2000). The Borana clans have lost a number of traditional wells and important wet season grazing areas to the Somali clans living in what is nowadays known as “zone five” in the course of cultural clashes with other ethnical groups.

3.1.2. The Borana land and culture in Kenya

Kenya is divided into nine **provinces**: Lake Victoria, Nyanza, Coast, Central, Western, North Eastern, Nairobi, Rift Valley and Lake Turkana. With the exception of Nairobi all provinces are divided into several **districts.** Marsabit is one of the 13 districts that form the Eastern Province and is situated between 01015´ north and 04027´north and longitude between 36003´east and 38050´east. Kenya has roughly 32 million inhabitants (year 2003) (FAO, 2004).

3.1.2.1. The Marsabit district

In total, the Marsabit district covers an area of 66,000 km^2 on an altitude between 300 a.s.l. and 2,500 metres a.s.l. with 28 locations and 65 sublocations. 72 percent of the area is non-arable land (Rural Planning Department, Ministry of Finance and Planning, 1999). Marsabit is furthermore divided into seven divisions: Central (1336 km^2), Gadamoji (614 km^2), Laisamis (11,547 km^2), Maikona (19,329 km^2), Loiyangalani (9,717 km^2), North Horr (18,401 km^2) and Lake Turkana (4,956 km^2) (Rural Planning Department, Ministry of Finance and Planning, 1999). The Central Division, where the research took place consists of five locations and 12 sublocations. 127,560 people inhabit Marsabit with an annual population growth rate of 2.8 percent (1999) and a total number of households of 30,000.

3.1.2.2. The Borana culture in Kenya

Pastoralist societies occupy 70 percent of Kenya’s total land but they number less than 2 million of Kenya’s total population of 30 million citizens (Fratkin and Roth, 2005, chapter 2) with only 90,000 belonging to the Oromo group, among which the Borana is also counted. The Borana are one of the resulting groups of Oromo-Borana migrants who left the southern highlands of Ethiopia and are believed to have reached Kenya between 1,400 and 1,500 with the largest expansion in the 16th century (Schlee, 1989). In any case, the larger share of Borana people still remains in southern Ethiopia.

About 44 percent of the Kenya Borana people live in the Marsabit District, in the Tana River District, Garissa District and the in Moyale District, together with Gabra, Rendille (including Ariaal) and the Sakuye people (Fratkin and Roth, 2005, Chapter 2). The heaviest concentration lies in the Sololo area of Marsabit District and in Moyale District. The Borana people in Kenya are closely related to the Gabra group mainly camel herding but also cattle nomads and commonly found in Marsabit district.

The Kenyan Borana people do not seem to pursue their traditional pastoral live depending on cattle production as seriously as their Ethiopian ancestors. The Kenyan Borana people do not follow the rules of a traditional *gada* system similar to the one that exists among Borana clans in Ethiopia. The tradition of digging deep wells has also never been practiced. Moreover, the type of agricultural production and the source of income have nowadays started to shift from livestock production to cash crop production such as the cultivation of the very profitable **miraa**[33] (also known as Khat - Catha edulis), whose demand is growing.

3.2. Genetic principles of cattle

The process of **domestication** began some thousand years ago (during the Mesolithic period around 8000–7000 BC (Zeuner, 1963)) and, by human **migration,** has widely spread reaching very remote areas. The domestication process played a decisive role in the development of genetically distinct **breeds**[34] through the combined response of these animal populations to **two interacting forces**: **selection** pressures imposed by **human** communities and **selection** pressures imposed by the ruling **environmental stress factors** which operate through differential reproduction and survival of parent animals and their offspring (FAO, 2000, p. 7). These two types of selection bring out characteristics of animals (and finally breeds) that are not necessarily strategic for survival but are **favoured** by man for **economic** or **cultural reasons**. The development of the species “cattle” and the further differentiation into breeds

[33] This plant is a natural stimulant derived from a shrub that flourishes in East Africa whose mildly narcotic leafs are chewed by many people in East Africa and the Horn. Most of the miraa from Marsabit district is either sold in Marsabit town or transported in pick-up trucks to Nairobi and eventually flown to Somalia where higher prices can be fetched. The twig is legal in Kenya and has become one of Kenya's chief exports, still behind tea but now ahead of coffee.

[34] The term “breed” is the most commonly used term to describe livestock populations or varieties. Clutton-Brock (1981) defines a breed as a group of animals that has been selected by man to possess a uniform appearance that is inheritable and distinguishes it from other groups of animals within the same species.

will be discussed in detail in the following chapter whereas details on the Borana breed are emphasised in Chapter 3.3.

3.2.1. Classification of cattle

All cattle are included in the genus **Bos**. Most cattle can be assigned to either the type **Bos taurus** or **Bos indicus**[35]. Bos indicus cattle are also referred to as **Zebus**. The two types can be interbred freely, there is no reproductive barrier. However, there are physical differences: Bos indicus cattle have a very pronounced **hump** on their shoulders, while Bos taurus cattle are humpless. Genetic evidence suggests two independent domestication events for Bos indicus and Bos taurus cattle (FAO, 2000). Bos indicus cattle originated in India and then began to migrate along the east coast of Africa and towards South East Asia. Bos taurus cattle are predominately found in northern areas of Asia and Europe but there were migrations along western Africa and America as well (Buchanan and Dolezal, 1999).

The exact origin of African cattle remains uncertain but it has now become widely accepted that Africa was a center of domestication with the center of breeding and domestication in Ethiopia (Bradley et al., 1996). In around 1 500BC, longhorn Bos taurus cattle were introduced into Africa and later on mated with humpless longhorn cattle in Ethiopia and Somalia, resulting in a subgroup, the so called **Sanga** cattle. Sanga breeds, which take advantage of the complementary characteristics of Bos taurus and Bos indicus strains, have been developed since the nineteen's century and can therefore be considered well adapted to the environment and accepted by farmers. Sanga cattle then spread from Ethiopia into central and southern Africa. In around 670 AD, short-horned Zebu cattle were introduced via Ethiopia and Somalia, largely replacing Sanga cattle from East Africa. Those Zebus were interbred with already existing Sanga, creating the **Zenga** type (Rege, 1999a). The short-horned Zebu cattle spread further westwards and southwards and became the dominant cattle in this area. There are 75 Zebu breeds in Africa, some 61 of these breeds are found in East Africa and neighbouring countries, the rest are represented in West Africa (Rege, 1999a).

3.2.2. The creation of breeds

The concept of a breed may apply to any group of animals which is located in a geographical area, which have some phenotypic characteristics in common and are recognized by the local people as a local type (Mason, 1996). **Pedigree recording** has enhanced this definition of "breeds" by supplying detailed parentage and relationship information for many of the

[35] The remaining small proportions of cattle belong either to Yak (Bos grunniens), Gaur or Mithan (Bos frontalis), Banteng (Bos javanicus) or Buffalo (Bubalus bubalis) (FAO, 2000, p. 8).

'developed' breeds but for most of the African breeds no recording of pedigree information exists. In North America and Europe cattle are subdivided into traits by **utility** like meat, milk or dual purpose. In addition, the most productive breeds usually only serve one purpose, either milk or meat production. However, many traits in Africa are **multifunctional** with additional utility such as traction suitability, manure use etc. and thus this research will refer to the classification of breeds by **evolutionary origin** (Bos taurus, Bos indicus, Sanga, Zenga) and by characteristics that are typical for certain breeds rather than the classification by utility. The local breeds of cattle kept in the research area are named after the ethnic group which introduced them. There are therefore Borana cattle, Gari cattle, Guji cattle, etc.

Four primary **mechanisms,** namely founder affects, migration, mutation, natural selection and selection by man, contribute to the final population and to the creation of a new breed (Clutton-Brock, 1981; Epstein and Mason, 1984). There is diversity in form of a few “options” for genetically controlled characteristics between breeds but the majority of the functional DNA is identical within a species because it codes critically important proteins, essential for maintaining a viable organism (Clutton-Brock, 1981).

The **founder affects** seem to play the most important role because a breed or population is largely dependent upon the genetic make-up of its founder group. This foundation group was in turn dependent upon the selection pressures it had previously encountered and upon the genetic make-up of its own founder group. Thus, as tribes of people migrated across the globe they took samples of their own livestock with them to their new homes. In each location the people and their livestock would adapt through selection which is the survival of those individuals genetically suited or able to adapt to the new environment. Due to the next human migration a sample of this population would then be taken to other areas. Again this sample would then be the founder of a new population and over time would have a slightly different genetic make-up. It might have still been the same breed but with a different genetic make-up. In the following chapter the meaning of the changing genetic composition owing to the founder affects will be pointed out.

Natural selection takes place when environmental pressures act on an individual which then will either succeed or fail in responding to that pressure. Only successful individuals will pass their genes onto the next generation. Natural selection results in the survival and successful reproduction of animals genetically adapted to that environment. The principal aspects of natural selection are nutrient supply, climate, parasites and predators and competition within the species. Gradual **inflow of genes**[36] has widely taken place as well, whereas **migration** rarely occurs.

Mutation plays a minor role in the creation of new genetic variation. It takes place due to spontaneous changes between the original and the copy DNA codes which makes it unpredictable and difficult to assess (FAO, 1999). These spontaneous changes result from either the mis-copying of the DNA sequence, spontaneous breaks and incorrect re-ordering of the sequence, or from damage to the DNA sequence which may be brought about by radiation (FAO, 1999). Mutation can sometimes cause more efficient functional genes but they more often result in non-functional or deleterious genes. Rates of mutation have been calculated to be in the order of 1 in 100000 per generation (Henson, 1992, Chapter 2.1).

3.3. The Borana breed, its status, and phenotypic description

The Borana breed is assigned to Bos indicus, a **breast hump** type of cattle. It belongs to the East African **Shorthorned Zebu** type (Payne and Hodges, 1997) and is raised primarily for meat production in intensive/commercial production systems but serves as dual purpose breed in small-scale production system as is the case among livestock-keepers in the research area. The Borana breed also belongs to the class of Large East African Zebus (ILRI, 2006a).

The breed shows high resistance to heat, ticks, and eye diseases; it can endure scarcity of water and can live on low quality feed and Borana cattle, which are noted for their docility, are highly fertile and mature earlier than most other Bos indicus breeds. (Mason, 1996, pp. 273). Livestock-keepers, like the Oromo-Borana, select animals for characteristics such as their ability to withstand periodic shortages of water and feed, digest low quality feed and walk long distances (Haile Mariam et al., 1998). The animals are mainly white or grey in colour but may also be red or pied. The horns are short, round in cross section, upright and thick at the base.

Four different **subtypes** of the Borana breed are known and currently kept on the Borana plateau in Kenya and Ethiopia: **Kenyan**[37] Borana (KB), **Ethiopian**[38] Borana (EB), **Orma**[39]

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[36] Gradual inflow of genes happened due to the migration of people and livestock and caused modification of every population that exists today unless the animals were kept in geographically isolated situations (e.g. islands).

[37] FAO (1999; 2005) and DAGRIS (ILRI, 2006a) use the name improved Boran(a) synonymously with Kenyan Boran(a). This is rather misleading because the original Kenyan Borana was “created” by Borana people who migrated from Ethiopia to the North of Kenya and this type actually differs from the improved Borana that has undergone many breeding initiatives in commercial settings.

[38] According to Rege (1999a) the Ethiopian Borana is similar to Somali Borana and the author simply refers to “Borana” when talking about the Ethiopian and Somali subtype.

Borana (OB) and **Somali**[40] Borana (SB) (see Figures 13 to 17 in the appendix for some pictures on Borana types). This is one classification largely found in literature but some authors have refrained from this "standard" classification to a more "practical" one for which the validation is founded on livestock-keepers' knowledge and opinion. Following this classification, two subtypes of the Borana cattle in the Ethiopian Borana zone can be distinguished: the traditional large-framed ***Qorti*** and the smaller ***Ayuna*** (Homann et al., 2003). Both subtypes have evolved through human selection along with adaptation to environmental changes but nowadays animals of both subtypes can hardly be identified. The subtype *Qorti* is said to be the **pure Borana** cattle that was initially raised for the purpose of pastoralism and in the standard classification scheme it can be referred to as **Ethiopian Borana** (EB). The smaller framed subtype, the *Ayuna*, is rather similar to the Orma Borana. It is noteworthy that these classifications are only from the perspective of **phenotypic** selection, as the collection of blood samples of cattle in the research area has hardly taken place and hence no reliable and far-reaching genotypic analysis has been carried out so far. This lack in the genetic analysis[41] hampers the clear classification of the Borana breed.

There is a fifth type of the Borana, the **improved Borana**[42] (see Figure 18 in the appendix) that merged with the OB but has undergone 70 years of selection for beef production in a favourable environment in the absence of shortages and trypanosomiasis (FAO, 1989). This type is the result of extensive distribution of Borana and its genetic material to other countries. Abroad, Borana cattle are frequently used for crossbreeding purpose with other highly productive breeds, resulting in what is known as synthetic breeds[43]. For beef purposes, an optimum crossbreeding system involves any Bos taurus beef sire and improved Borana cows. Holstein-Friesian cows are usually interbred with Borana sire when aiming at obtaining improved types for milk purpose. An improvement of types for dual purpose is best archived by introducing dual-purpose breeds such as Red Poll and Brown Swiss or even Hereford, Charolais and Angus (Boran Cattle Breeders Society, 2006).

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[39] See Simianer et al. (2003) and Hanotte et al. (2000)

[40] See Rege (1999a)

[41] Genetic analysis such as molecular genetic measurement of genetic distances with DNA markers.

[42] In some studies, the Kenyan Boran(a) is referred to as improved Borana but in the present study the improved and the Kenyan Borana are treated as different types.

[43] Synthetic breeds result from an initial crossing of the indigenous breed with the exotic breed(s) using the latter as the sire breed, then selecting the resultant F1 individuals and inter-seminating them. Over generations, through selection, the population stabilises with intermediate genotype developed in which 50 percent of additive effects of either breed are retained, and 50 percent of the maximum heterosis effect maintained (Karugia et al., 2001).

One driving point in the decision for the Borana breed as research "object" was that the animals of the Borana breed are very heterogeneous and no real classification exists, apart from the rough idea of the Borana subtypes and a classification of the Borana in Ethiopia into ***Ayuna*** and ***Qorti*** type. This rather confusing classification does not ease the decisions over conservation initiatives because one does not know which of these types resemble the "original" Borana breed, i.e. which is the "purest" one, containing the entire desirable genes which should be conserved for future use. What makes decisions over conservation initiatives for the Borana cattle even more difficult is the fact that no **pedigree recording** exists for it (except of herd books for the improved type of Borana on commercial ranches). Further making the idea of conserving the Borana breed so appealing is the fact that the breed evolved approximately 1000 years ago. Hence, a loss of this breed and its genetic material would be a misuse of all these years of development, for which many local people contributed all their knowledge and experiences in cattle breeding. The Borana breed is also one of the breeds upon which many people heavily rely for their livelihoods. As will be shown in the next section, Borana cattle have to face many different threats to survival and that makes them vulnerable and hence a good target for a study on conservation strategies. Finally, the fact that the **superior performance** of this breed is widely recognised by local authorities and also by scientists and breeders outside East Africa, made this cattle breed an ideal target for research in order to better understand why, despite this recognition, the pureness of this breed is in jeopardy of becoming extinct.

3.3.1. The geographical distribution of Borana

The Borana breed originated in **South Ethiopia** and the neighbouring parts of Somalia and northern Kenya, and is now also being distributed over other areas of Africa. According to the World Watch List (FAO, 2000) Borana cattle stocks can be found in the Democratic Republic of Congo, Ethiopia, Kenya, Malawi, Somalia, Zambia, South Africa, Tanzania, Uganda, and outside Africa in Mexico and Australia. In addition, according to the Boran Cattle Breeders Society (2006), the breed is also common in Zimbabwe. Figure 2 shows the **Borana gene flow** within the African region and exports to other continents. The information was gathered from four sources: the two databases DAD-IS (FAO, 2005) and DAGRIS (ILRI, 2006a), the Boran Cattle Breeders Society and from own field research. See also Figure 1 in Chapter 4 for a sketchy section of this map showing only the research area.

The Borana cattle in **Kenya** that were developed from cattle of the Borana people of southern Ethiopia are most common in the South-Eastern districts Narok and Kajiado (both having boundaries to Tanzania), in Samburu and Isiolo (both in the northern lowlands) and in Marsabit and Moyale, both bordering on Ethiopia.

The Borana stock in **South Africa,** for instance, has been classified as critical (FAO, 2000, p. 83) with a stock[44] of females of 30 in 1998, mainly found in Kwa-Zulu-Natal. It has recently been imported from the main population in Kenya and also from Zambia and is raised in South Africa for meat purposes. Apart from the Borana status in South Africa no assessment in other countries is available as part of the World Watch List (FAO, 2000).

The **improved Borana** can be mainly found in the highlands of central Kenya from where it has recently been exported to other countries such as firstly USA (between 1970 and 1990) and South Africa and later in 1990 Australia (FAO, 1999; FAO, 2005; ILRI, 2006a) and Mexico. The Borana has been introduced to those parts of these countries that show similar harsh environmental conditions as in the Ethiopian and Kenyan lowlands (e.g. to Texas and to the Australian Outback).

The Borana stock in **Zambia** has developed through imports from Ethiopia. Zambia is nowadays one of the African countries (besides Kenya), where the Borana breed is subjected to an advanced breeding programme on a commercial farm, including the crossing with “exotic” high-yielding breeds. From Zambia, the improved Borana breed was further exported to South Africa in the year 1995 (FAO, 2005) and Australia. The other center for Borana breeding can be, without doubt, found in Central Kenya, where Borana cattle from the lowlands (southern Ethiopia and northern Kenya) are crossbred with “exotic” cattle breeds. From Kenya many exports have taken place, as for instance, to Australia in 1990 (FAO, 2005), to the USA (ILRI, 2006a), and to South Africa in 1994 (FAO, 2005) but also to many neighbouring African countries (see Figure 2).

[44] The population figures refer to registered animals only.

Figure 2: The Borana gene flow

The red circles mark the Borana breeding centers, the red square the center of origin – the map was taken from the United Nations Cartographic Section (http://www.un.org/Depts/Cartographic/english/htmain.htm)

3.3.2. Existing conservation programmes for Borana cattle

In the Kenyan research area, no conservation programme on private or governmental ranches is known until the time of this study. It is safe to say that in Kenya the focus of breeding strategies lies in the improvement of the highly productive Kenyan Borana and exotic breeds, almost neglecting local breeds that are kept by livestock-keepers in marginal areas.

In the highlands of Ethiopia, on a governmental ranch (**Abernossa Ranch**), improved crossbreeds between Borana cattle from the Borana lowlands and Holstein-Friesian[45] cattle are being kept and continuously improved. Every year these crosses are distributed to local livestock-keepers in the highlands in order to upgrade their herds in terms of productivity and therefore support their income generation. Additionally, the governmental ranch near Yabello on the Borana plateau (**Did Tuyura Ranch**) aims to conserve the pure Borana cattle. The ranch was established in 1987 when it received some of the best Borana animals[46] from Borana livestock-keepers and, owing to these animals, initiated a breeding programme. Since then, the ranch has been allotting breeding bulls to the five districts (*woredas*[47]) on the plateau in annual regularity. The breeding bulls are then further distributed to some communally selected livestock-keepers within the *woredas* for the purpose of upgrading their herds in terms of productivity and body size of the animals. The number of Borana cattle given out to each *woreda* depends on its population size: the Yabello district, for instance, obtained 18 bulls in 2003 but only six bulls in 2004. In total, 61 bulls were distributed in 2003, and 45 in 2004. The **price level** at which the animals were released differed a lot among recipients. The local Borana livestock-keepers initially sold their animals at 2000 Birr (= 200 €) per head to the Did Tuyura ranch. Offspring from the ranch was allocated, on the one hand, to Borana communities and, on the other hand, to the Abernossa governmental ranch. Borana communities are entitled to buy only bulls, but at a very fair price at 500 Birr per bull. The bulls were sold by the age of three. All heifers from Did Tuyura were further distributed to the Abernossa ranch and no money change hands. At the Abernossa ranch, the Borana heifers were crossbred with Holstein-Friesian and this improved crossbreed was continuously being sold to farmers/livestock-keepers in the more fertile Ethiopian highland regions at 2000 Birr per animal. The Abernossa ranch is the biggest beneficiary from the high quality Borana animals from Did Tuyura ranch.

The Did Tuyura Ranch constitutes a first attempt to conserve the large-framed pure Borana breed (the *Qorti* type) but it cannot fulfil the **high demand** of the livestock-keepers that clearly exceeds the supply of these few bulls for the entire Borana plateau. Moreover, the

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[45] Holstein-Friesian cattle can be considered an "exotic" breed, i.e. a high productive breed that emerged through intensive selection and that have been imported from Western countries.

[46] The selection of the "best" Borana animals entering the ranch was based on phenotypic characteristics. However, one cannot infer from the phenotypic make-up the genotype of an animal and hence, the pureness of these Borana cattle entering the conservation programme was never confirmed in the first place. Determining the genotype of a breed requires a molecular genetic analysis (see Hanotte et al., 2000).

[47] The five *woredas* are: Tatalde, Dire, Moyale, Arero, and Yabello.

ranch only facilitates up to this time the **upgrading** of the local peoples' Borana cattle as it distributes only breeding bulls and no cows. The Abernossa ranch is the biggest beneficiary from the high quality Borana animals from Did Tuyura ranch.

3.3.3. Benefits of the pure Borana breed and of its conservation

In the next two chapters the relative benefits of Borana and its real threats are described. The relations are established with regard to other local breeds and to so-called "exotic" breeds[48] that in the worst case scenario, eventually find their way into the Borana lowlands. The reason for this fear lies in various threats that are already present or that are not yet serious bur are forced by adverse policy implications. The threats are issued in chapter 3.3.4.

The benefits for the local livestock-keepers were extracted in a pilot study that was conducted prior to the CE survey and are manifold. Above all, the breed **secures** to a large extent livestock-keepers' **livelihoods** that almost fully depend on Borana cattle, not only as a source of **income** and daily **food supply** but also in **multiple functions** such as traction and manure provision. Borana cattle can only provide these benefits to local livestock-keepers because they show high **adaptation ability** to harsh environments including the ability to withstand droughts, heat and water shortages and a high level of tolerance (ticks and even trypanosoma). These factors make the Borana breed so unique and important for the dry lowlands that a decline, or even loss, in its genetic material providing these traits would result in a threat to the livestock-keepers' livelihoods because other breeds cannot provide the same benefits. Furthermore, maintaining the Borana breeds means preserving the **cultural heritage** of the Borana clans and enhances their cultural distinctiveness by securing continuous traditional livelihoods with cattle production. Shifting to other species like goats and camels does not go hand-in-hand with the Borana traditional way of life and this needs to be kept in mind.

Table 1 highlights the main attributes that are important for the quality of cattle, as stated by village elders in the course of focus groups and in-depth interviews. The table also attempts to rank the three predominant Borana subtypes (EB, SB, OB), and admixtures (Borana crosses with Gari, with Guji and with SEAZ) with respect to the performance of the different traits. It is important to emphasise the country-specific differences among the Borana crosses. Borana crosses in Ethiopia mainly consist of Borana with Guji admixtures while in Kenya Gari and Small East African Zebus (SEAZ) are interbred with Borana.

[48] "Exotic" breeds are high potential breeds that are imported from other countries, not only from neighbouring countries, but also from North America or Europe. In the study area, they mainly comprise of Hereford and Charolais.

Table 1: Livestock-keepers preference ranking of attributes among local breeds

		Breed and subtype					
Attribute	**Measured through**	**OB**	**SB**	**EB**	**B*SEAZ**	**B*Guji**	**B*Gari**
High tolerance to environmental extremes such as droughts	Watering frequency	2	**1**	**1**	3	3	2
Ability to cover long distances	Body size	2	**1**	**1**	3	3	**1**
High level of tick tolerance	Tick tolerance	**1**	**1**	**1**	3	2	2
Great cultural value	Horns size and shape; Body size	2	2	**1**	3	4	3
Insurance for emergency cases (ability to fetch high prices at market)	Market price	3	**1**	2	4	4	**1**
Good mothering ability and high fertility	Calving frequency	**1**	2	2	3	3	3
High milk yield and good udder condition	Milk quantity	2	2	**1**	3	2	1
Traction suitability	Traction suitability; Body size; Horn size and shape	**1**	2	**1**	3	**1**	**1**
Strong mating activity and strong offspring	Offspring strength	**1**	**1**	**1**	2	2	**1**

The ranking clearly reveals advantages for the Borana breed in general and for the Ethiopian and Somali types in particular, this holds true especially with respect to tolerance to water shortage, fertility, tick tolerance and cultural value. Some other attributes such as the ability to cover long distances due to large body size, milk yield and traction suitability are perceived as excellent equally for Borana and Gari cattle. As also shown in the ranking, the Guji and SEAZ breeds did not in any case perform as well as Borana and Borana/Gari crosses.

3.3.4. Threat to the pure Borana cattle in Kenya and Ethiopia

The effective threats which the Borana cattle face are manifold and exceed the major ones that have long been recognised, such as declining availability of pasture, population pressure and increasing crossbreeding (see Chapter 1). The main problem is not so much a declining **population size** of pure Borana animals[49] (at least not in "normal" seasons), but the dilution of the genetic material of those animals that are existing in the research area. The study reveals that the major driving factors that put the existence of the pure genetic material of the Borana breed into jeopardy are partly **country specific**.

Population pressure is one of the most severe problems occurring in both countries which leads to a decline in the number of cattle and other livestock in general and forces people to minimise their herds because of **scarce pasture.** All of the land is **common property** and people settle and establish new villages wherever they see fit. (Coppock, 1994). These were often fertile pastures that were formerly used as *foora* pastures for pastoralists wandering with their herds from one water point to the next and thereby preventing overgrazing. Borana

[49] According to the database DAGRIS (ILRI, 2006a), the population size of Borana cattle in Ethiopia and Kenya ranges between 10,000 and 40,000 for male (depending on subtype and country) and 10,000 and 100,000 for female animals. These numbers are well beyond the level that assigns a breed "at risk" (see FAO, 2000).

people in Ethiopia had their own rules (embedded in the *gada* system, see Chapter 3.1.1.1.) for sustainable use of natural resources but have now been forced to settle down and adapt to other production schemes such as crop production for a daily life. Besides population pressure, there are various underlying causes for the genetic erosion of the Borana breed in the research area. In Ethiopia, the most important ones include: changes of ecological characteristics due to bush encroachment and recurrent droughts, poor herd management, difficulties in access to markets, and civil strife (Coppock, 1994; Reda, 2001; Alemayehu and Drucker, 2002). **Bush encroachment** became a serious problem and is probably the second severest threat after **scarce availability of pasture** due to population growth, increased area under cultivation, gazetting of parks and protected areas, and violence (Coppock, 1994). Bush encroachment has arisen as a result of the absence of range fires[50], leading to diminishing availability of good pasture and hence, to a decline in cattle carrying capacity per unit grazing area (Coppock, 1994; Hogg, 1997).

C**hanges in production systems** have also adverse effects on the existence of the pure Borana breed because pastoralists started to abandon their reliance on pastureland and grassland and become farmers with additional keeping of **small stock** and reduced, if they had any, herds of cattle (see Table 6 in Chapter 4: only 17.1 percent of respondents in Ethiopia admitted to being purely pastoralists anymore, compared to the bigger share of 59.7 percent of respondents in Kenya). The **diet pattern,** which in the past was largely based on animal protein, has now changed to calories from crops, and most commonly maize. That fact further enforces settlement of people and drives them to change their production from purely cattle herding to agro-pastoralism.

The **replacement** of cattle by small stock and camels is a further serious problem taking place to the largest degree in Ethiopia. In Kenya this **replacement with other species** has not been found to be as intensive and alarming as in Ethiopia. The changed environment on the Ethiopian Borana plateau is more and more only suitable for grazers anymore, not for browsers, as cattle and hence livestock-keepers switch to goats and camels. Such species substitution threatens the Borana traditional way of life in Ethiopia because the husbandry of goats requires permanent settlement. That is because unlike cattle, goats cannot be herded over long distances and cannot stay without water for many days. Livestock-keepers in

[50] The Borana people used to practice range fires as a means of renewing pasture and to suppress bush encroachment and resulting venomous reptiles and animal pests such as ticks (Huqqaa, 1998). The government (the *Dergue*) banned range fire in 1974. As a result bushes widely spread suppressing the growth of grass. The burning of old pastures and grass also long helped to control ticks. Now the regular use of acaricides in dipping or spraying is the main way to overcome tick infestation.

southern Ethiopia do not only switch from cattle to other species, but also from keeping the large-framed Ethiopian Borana breed to Orma or Somali Borana and other local breeds or crossbreeds.

As already mentioned, in Ethiopia, pastures used to be common property of Borana clans and communities, accurately defining the community's **rights over grazing land**. Everybody belonging to a particularly clan or community had the right to use the pastures for grazing their cattle, including water points (particularly deep wells). Just recently, a **change in this property rights** regime took place and grazing land was assigned to individual livestock-keepers or, in the worst case, was taken away from the government which used it for other purposes. The traditional regulation of common property bore, on the one hand, one disadvantage, namely that of arbitrary sedentarisation of families on former good pastures due to population pressure. On the other hand, this regime secured sustainable use of natural resources over centuries and **overgrazing** had never been a large problem within the Borana zone. In the context of the new wave of "privatisation" of common land in order to increase productivity and efficient use of resources one would argue that assigning land to individuals households was a good thing to do. Households use the **private plots** to change them to arable land (if possible). In the course of the survey, the impression also arose that livestock-keepers did not feel responsible anymore for their grazing lands than they traditionally used to be. Their focus and responsibility have largely shifted to their individual plots and agricultural cultivation.

Continuing with **Kenya**, the good linkage to the **Nairobi market** (which will further improve due to the tentative construction of a tarmac road from Moyale to Nairobi via Marsabit) constitutes one major threat, as well as the frequent exchange of livestock between the lowlands and the central highlands. Unlike rural southern Ethiopia, a market for exotic breeds is strongly present in the rural areas of northern Kenya. The livestock-keepers' attitudes towards the importance of keeping exotic breeds in the herd strengthens this threat (see Chapter 7.2). The **opening up of markets** has to be treated cautiously as Alemayehu and Drucker (2002) argue that the genetic erosion of Borana cattle could also be triggered by the improvement of access to markets, as livestock-keepers are able to substitute the Borana with other higher output breeds. In Kenya, cattle production is more market-oriented than in Ethiopia and **higher prices** can be fetched when selling animals on Kenyan markets. The higher market prices is what leads to increasing numbers of livestock-keepers in Ethiopia (illegally) crossing[51] the border and selling animals in Kenya. That is particularly true for the market in Moyale, a city divided into a part belonging to Kenya and one to Ethiopia. In any case, with Ethiopian livestock markets on a rise in popularity and efficiency (there are no straight rules or auction systems hitherto but a change is on the agenda), Kenyan markets in the research area are still better developed, bigger and show a higher transaction rate. Kenyan markets are usually characterised by well organised **auction systems** with permanent staff employed being responsible for carrying out the auctions. Although the main road to Nairobi is not in good condition[52], it does not seem to hamper the transport of livestock from Moyale to Nairobi markets. Many lorries packed with live animals leave Moyale daily in order to meet the growing **demand for meat** in Nairobi and other large cities in Central Kenya. However, the opening up of markets has to be treated cautiously as Alemayehu and Drucker (2002) argue that the genetic erosion of Borana cattle could also be triggered by the improvement of access to markets, as livestock-keepers are able to substitute the Borana with other higher output breeds.

In Kenya the improvement of cattle for meat production is an ongoing (presently very vigorous) issue and **artificial inseminations** and **embryo transfers** have long been used making Kenya in no way inferior to Western countries when it comes to the effort of increasing productivity in cattle.

Breeding societies have emerged in Kenya in the last decades, providing an optimal platform for research and information exchange. The use of improved breed and exotic genetic material has proved to be very successful on large private and public commercial farms because of the fertile highlands supplying ideal requirements for intensive livestock production. However, improved breeds and exotic genetic material have begun to spread over the boarders of the Central highlands and no halt is being made in the lowlands. Improving **information channels** also makes livestock-keepers in northern Kenya more aware of alternative breeds and breeding methods that eventually could lead to an increasing production. Hence, even livestock-keepers in the lowlands are keen to introduce improved breeds as replacement for

[51] It is noteworthy that, in particular local livestock-keepers in Ethiopia, are often not positively affected by a higher market price because **brokers** are almost often involved, buying Borana animals from the local communities at the "normal" low price and sell them further to the next bigger city before they are eventually transported to urban markets. That is the reason for illegal border crossing to the Kenyan markets in Moyale. The existing local markets in Ethiopia have lower prices, while the link between lowland (where the Borana plateau is located) livestock production and markets from the highlands which have wealthier populations, is very poor or even completely absent (Reda, 2001).

[52] That is because the former government (the Moi regime) long failed to distribute international aid money to the construction of a tarmac road that initially should have connected cities as far from each other like Nairobi to Addis Ababa.

their local ones, including “exotic” breeds, in the hope of higher production and higher income from market sells. For example, Karugia et al. (2001) estimated that crossbreeding has increased Kenyan social welfare by almost 37 million USD annually and these economic benefits from crossbreeding cannot be ignored. These benefits, however, largely stem from the introduction of new efficient and productive **technologies**. This technical change has put increased economic pressure on more traditional land-intensive grazing methods causing many livestock-keepers in Kenya to abandon indigenous breeds. The adaptation of these improved or “exotic” breeds goes along with an analogous **substitution of local breeds**. This problem is definitely more serious in Kenya than in Ethiopia and the fact that Kenyan livestock-keepers seem not to be so much involved **in traditional rites** that embrace cultural aspects of livestock make them even more receptive to the introduction of new breeds. They do not associate themselves and their everyday life with a particular breed but more or less only with **productivity** and large herds seem to drive their breeding decisions. This leads to the conclusion that in Kenya the interspecies substitution of breeds is largely from Borana cattle to high-yielding breeds and their crosses whereas in Ethiopia the Borana breed is rather being replaced by other local breeds.

Finally, **settlement programmes** in Kenya aggravate the problem of sedentarisation[53] and the resulting overgrazing and change to crop production. Prior to 1960 the Kenyan government organised the transfer of some populations from severely over-populated areas to those areas which were either uninhabited or only sparsely populated (Fratkin and Roth, 2005, Chapter 2). The aim of such a program was to relief population pressure and it was done quite successfully by giving people individual plots for cultivation. As people, however, were resettled in areas that used to supply good pastures the entire program was harming livestock keeping. These resettlement programmes did not take hold of the lowlands. There have never been any attempts to reorganise, and hence people just settled down and exploited the land.

A further problem that arises in Kenya and to some extent also in Ethiopia is related to adverse policies and takes effect soon on the recent occasion of the drought in East Africa. **Restocking** of entire herds is done quite quickly after the drought with small Highland Zebu cattle breeds. They are not as adapted as the Boran breeds but serve quite well for the purpose of compensate livestock-keepers in terms of animals. These Zebu breeds are eventually

[53] Sedentarisation is the process of individuals, households or communities of formerly nomadic populations settling into sedentary, non-mobile, and permanent communities (Fratkin and Roth, 2005, p. 8). It is also possible that pastoralists settle with their families in order to take advantage of schools, dispensaries, and markets near town but some household members remain nomadic to pursue herding (Little, 1992).

crossed with Borana animals that survived the drought, obviously leading to further genetic dilution of the Borana breed.

3.4. Summary

Chapter 3 gave a background on, firstly geographic aspects of the research area, and secondly, on the Borana culture in Ethiopia and Kenya and on the society's livestock in particular. The chapter thereby focused on the countries' differences in traditional cattle husbandry and in the way livestock-keepers pursue a livelihood based on cattle production. The strong affection of Ethiopian livestock-keepers for the Borana culture, embedded in the traditional *gada* system, and the traditional division of their pasture into *foora* and *warra*, thereby ensuring a sustainable use of natural resources, were highlighted. The chapter also showed that Kenyan livestock-keepers are nowadays more market-oriented and are moving away from traditional cattle husbandry to more profit-oriented crossbreeding schemes, often involving exotic cattle breeds.

Further, this chapter gave a background on the genetic principles of cattle, and the Borana's ancestry from the Bos indicus, the humped type of the genus Bos. The classification of the Borana breed into four different subtypes, the Ethiopian Borana, Orma Borana, Somali Borana and Kenyan Borana was described, emphasising the superior productivity of the Kenyan Borana type earning it the name "improved Borana". It was also explained that the Ethiopian Borana subtype is considered the pure Borana, containing the breed's original genetic material.

From there, the chapter continued with the global and regional distribution of the Borana breed and gave some information on imports and exports of Borana genetic material. It was pointed out that Borana genetic material had long been exported first of all from the Borana zone to urban areas, including Nairobi and Addis Ababa and from there further to other African countries and even to some Western countries. The gene flow within Ethiopia seems to be rather endogenous with only little external movement, though, accounted for by illegal selling. One reason for these regionally constrained movements, the government-driven conservation programme that is in place for the Borana breed in Ethiopia, was described. To the contrary, it was shown that the gene flow in and from Kenya has taken on global dimensions.

The chapter concluded with country-specific benefits and threats of the Borana breed and its different subtypes. Manifold benefits were revealed due to the expression of unique traits of Borana cattle, such as excellent adaptive and cultural traits but also productive traits, varying between the four Borana subtypes. It was shown that these benefits secure to a large extent livestock-keepers' livelihoods that almost fully depend on this breed. To summarise the threats of the Borana breed to survival in both countries, it can be said that in Ethiopia the problems are more environmentally driven whereas in Kenya the main threats are caused by market or political forces. However, genetic dilution due to crossbreeding is one of the most severe threats in both countries.

CHAPTER FOUR

Study area and methodology

4. Study area and methodology

Chapter 4 addresses the issue of how the data for the CE was gathered from a sample population in the first place and how the experiment was structured. The description of the experimental design (ED) includes the attributes and levels that are then finally combined into animal profiles and then into choice sets. The coding procedure will also be described before this chapter closes with a presentation of the results of household survey data on socio-economic aspects of respondents.

4.1. Sampling and data collection

This section provides a description of the underlying sampling theory that motivated the selection of different areas where the survey had finally been conducted. The data gathering process for this study includes two stages that require different strategies: first of all, the sampling of individuals taking part in the survey, and secondly, the sampling of animal profiles from a complete set of profiles. The first issue is addressed in Chapter 4.1.1. while the issue on profiles is part of the designing of successful CE (see Chapter 4.2.2). The main field research took place between October 2003 and January 2004, the pilot study was undertaken between June and July 2003.

4.1.1. Sample frame and sampling strategy

The **sample frame**[54] or target population, representing all individuals that are of interest to this specific study and from which the **sample**[55] will ultimately be drawn, consisted of all **livestock-keepers** possessing at least one cow or bull. It was not very difficult, though, to obtain this sample frame because almost all people in the research area live from cattle production. A brief question on the number of cattle was presented ahead of the interview in order to ensure only inclusion of respondents who keep cattle and thereby making certain that a good knowledge about cattle production was available. **Experience** in cattle production was essential for participation in the CE. In the rare case where households only kept small livestock (goats and sheep) the interview was **closed** and not included in the data analysis.

[54] The sample frame must be consistent with the target population. The ideal frame is one where every member of the target population is listed once and only once (Bateman et al., 2003). This makes it possible to select a random sample from the frame without having to worry about under- or over-sampling some particular subset of the target population. A "wrong" sample frame can lead to what is known in as coverage error or sampling frame bias (Bateman et al., 2003). Coverage error is one potential source of survey error.

[55] The sample is a limited number of individuals representing the characteristics of an entire population (Dibb et al., 1997, p. 180).

Multistage stratified sampling[56] was applied to this study. Therefore, in a first step, the two neighbouring countries Kenya and Ethiopia were sampled and in a second step both samples were further stratified by **probability sample**[57] into two zones in Kenya and three districts in Ethiopia and in a further step into locations (in Kenya) and PAs (in Ethiopia). In order to avoid complications it will be simply referred to as the (research) areas from now on. The five areas and their smaller units (in Ethiopia "PAs", in Kenya "locations") were selected intentionally due to the kind of Borana subtypes predominantly found in the areas. The aim of the sampling was to target the most **diverse** populations and samples as possible in terms of the differences in their Borana cattle breed. Chapter 4.1.2 explores the diverse characteristics of the research areas in more detail.

Households were then selected within each of the five areas by the method of s**imple random sampling**[58] (SRS). The SRS was considered the best method subject to feasibility and time constraints and it also aimed to minimise survey errors (Bateman et al., 2003, Chapter 3). The underlying sampling framework's main problem, which possibly, bears the risk of **sampling errors** as a result, was the lack of complete and official **directory** of households on the district and village level. The problem was solved by obtaining household lists from village chiefs from which a certain number of household were randomly selected. Due to the sparsely populated areas in northern Kenya and southern Ethiopia, the difficult access to villages and the fact that a large share of households live as pastoralists, made it sometimes infeasible to target the randomly selected household. In that case, the household whose name was listed right above the initially selected one was targeted instead.

4.1.2. Sample size and distribution

For a CE it is important to have a sufficient number of choices made by representative households. Therefore two numbers are of importance: the **sample size**, i.e. the number of

[56] In a stratified sampling approach the population is divided into two or more strata and each subpopulation is sampled (usually randomly). Each stratum must share the same characteristic (Dibb et al., 1997, p. 180). Stratified sampling is a way of probability sampling and in 1939 a consensus had developed among mathematical statisticians that "the stratified random sample is ... the only practical device now available for securing a representative sample from human populations" (Snedecor, 1939).

[57] Probability sampling permits the use of statistical theory to derive the properties of the sample estimators and hence, each element in the population frame has a known and non-zero probability of being selected. The selection procedure involves the use of a randomized procedure, such as a computer-generated list of random numbers (Bateman et al., 2003, Chapter 3). Probability sampling is nowadays recognized as the "gold standard for survey sampling" (Bateman et al., 2003, Chapter 3).

[58] In a simple random sampling every element of the sample frame is given an equal chance of being selected (Louviere et al., 2000).

respondents undergoing the entire survey, on the one hand, and the number of **replications** of choice tasks, on the other hand. Each respondent was asked to answer four choice sets for cows and three for bulls and each task involved making three choices. Hence, the total amount of choices obtained from one respondent equals 7*3=**21 choices.** Although the strategy of multiple choices for each respondent ensures the great advantages of saving a lot of time and money it must also be ensured that respondents treat each choice set as unrelated to previous ones in order to guarantee that choice observations are **independent** (Louviere et al., 2000, p. 263).

The sample size in each country was simply motivated by a **rule of thumb** suggesting that the sample should still be large enough even when it is divided into groups. Each group will have a minimum sample size of 100 or more (Seymour, 1976, p. 50). Therefore, the sample size for Ethiopia amounted to 246 households (incomplete questionnaires already deducted) and for Kenya to 124 households. Taking into account the 21 choice reapplications made by each respondent, 5166 choice observations were obtained from the Ethiopian sample and 2604 observations from the Kenyan sample.

On the Borana plateau in Ethiopia four peasant associations (PAs[59]) were targeted for this field research: Didi Hara (in Yabello district), Web (Arero district), Wachile (Arero district) and Finchawa (Bule Hora district). The distribution of the respondents among the three districts and four PAs is shown in Table 2. In Kenya respondents were selected out of two zones within the Marsabit district[60], namely Central Marsabit and Burbisa as shown in Table 3. Again, the sample size of the subgroups in each country was roughly defined based on Seymour's (1976) recommendation of a minimum size between 20 and 50.

Table 2: Distribution of interviewees among districts and PAs in Ethiopia (in heads)

PA	District			
	Yabello	Arero	Bule Hora	Total
Didi Hara	100	-	-	100
Web	-	97	-	97
Wachile	-	27	-	27
Finchawa	-	-	22	22
Total	100	124	22	246

[59] The PAs were created under the Land Reform Proclamation Act (1975), as a means of organising the livestock-keepers into territorial units (see Chapter 3.1.1).

[60] The administrative boundaries in Kenya are organised in provinces, districts, divisions, locations and sublocations as smallest unit (see Chapter 3.1.2).

Table 3: Distribution of interviewees among zones and villages in Kenya (in heads)

Location	Zone		
	Central Marsabit	Burbisa	Total
Rukesa	30	-	30
Badasa	20	-	20
Kijiji	30	-	30
	-	44	44
Total	80	44	124

The two research countries have two important and linking characteristic in common; firstly the importance of cattle, in particular of Borana cattle, to the daily life of the population, and secondly, the fact that the majority of the population belong to the Oromo-Borana cultural group and hence are traditionally presumed to pursue an existence based on cattle production. Otherwise, the different districts within a country were chosen in order to have the largest **variety** within the target population and the sample.

Table 4: Heterogeneity in sample

Research area		Characteristic			
		market	culture	artificial water	arable land
Ethiopia	Didi Hara	+	-	+	-
	Web	-	-	-	-
	Wachile	-	-	-	-
	Finchawa	+	+	+	+
Kenya	Rukesa	+	+	+	+
	Badasa	+	+	+	+
	Burbisa	-	-	-	-
	Kijiji	-	+	+	-

Four criteria were basically decisive in defining variation between the research areas: the linkage to a nearby **market** and/or a main road (variable "market", marked "+" when a nearby market and/or road existed), heterogeneity in **cultural groups** which still engaged in livestock production as a living ("culture"), the availability of artificially constructed **water points** ("art. water"), and the availability of **arable land** that is fertile enough to support crop production in a larger extent, i.e. not only in terms of small plots for self-consumption ("arable"). Table 4 shows how the research areas were characterised in terms of these four criteria. The criteria "market" and "arable" were later on included in the economic model as dummy variables (see Chapter 5) characterising the type of production system.

Figure 3 depicts the distribution of the Borana subtypes that are kept in the research areas which was why these areas were targeted in the first place. The bordered areas thereby demonstrate the research areas. Table 5 provides the respective sample size of households keeping a particular subtype of Borana cattle. The initial goal was to target a sample size of at least 100 households characterised by each Borana subtype as was the case for EB and OB. Interviewing households keeping the **SB** bore some problems related to the ongoing dry season and delay in expected rains and hence the absence of households and cattle herders living sedentary near or in villages. The area around Burbisa in Kenya where the Somali Borana is commonly found is known for its dryness and inability to be cultivated and thus the only production system that allows food production is pure pastoralism and **nomadic life**. That made the sampling and targeting (and primary the discovery) of numerous households for interviews very difficult and that also explains the low sample size of 44 households. Burbisa is furthermore the only location in which the subtype could not clearly be distinguished. The SB type is dominant in the northern and eastern parts around Burbisa whereas the EB subtype can be found mainly south and west of Burbisa. The sample size for households keeping **Borana crosses** was also relatively low (52). The reason for that was that the taste preference of livestock-keepers for crossbreeds was not considered as important as the preferences for the different Borana subtypes. These interviews were rather taken with the objective of drawing a comparison among livestock-keepers originally maintaining Borana cattle and those who either have changed from Borana to improved crossbreeds or are aiming to switch from other local breeds to Borana and hence started to inbreed Borana genetic material into their herds.

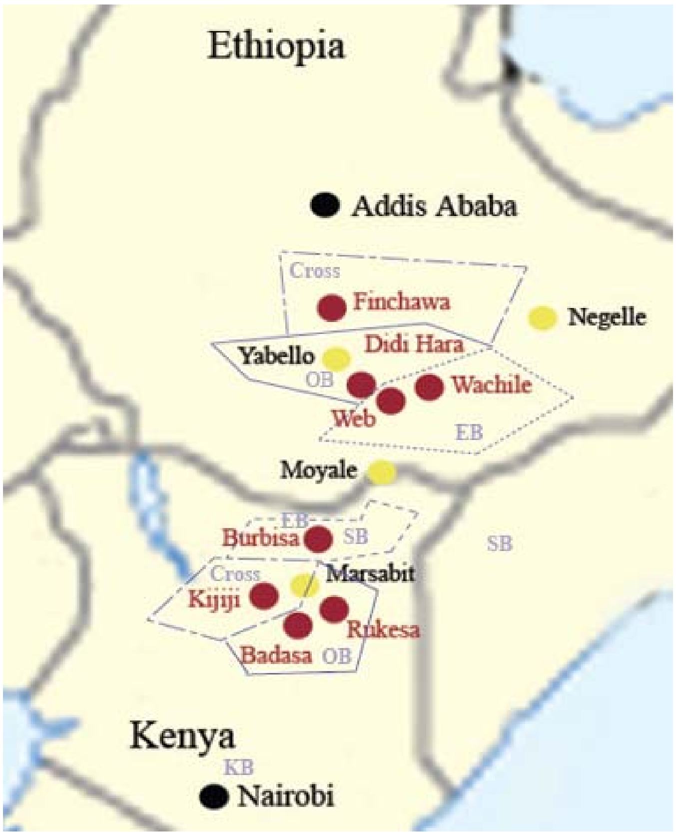
Table 5: Distribution of interviewees among areas of Borana subtype dominance

Research area	Borana subtype			
	EB	SB/EB	OB	Crosses
Didi Hara	-	-	100	-
Web	97	-	-	-
Wachile	27	-	-	-
Finchawa	-	-	-	22
Rukesa	-	-	30	-
Badasa	-	-	20	-
Burbisa	-	44	-	-
Kijiji	-	-	-	30
Total	124	44	150	52

Households in areas where the **Kenyan Borana** type is dominant were not included in the entire survey because revealing taste preferences for this type is not the scope of this research. As already mentioned in Chapter 3.3, the Kenyan Borana is not deemed to be at any risk and does not require any conservation initiatives and, more importantly, due to clearly defined breeding plans, demand orientated marketing and continuous improvement sufficient data on its traits and value have already been extracted and provided to the public in numerous publications of scientific literature.

The **distribution** of the Borana subtype was not entirely known prior to the main survey but some information could be gathered in the pilot study phase (consisting of focus groups interviews and some in-depths interviews with village chiefs) and based on those results, areas were then selected for the survey as shown in Table 5. A problem arose through the fact that the livestock-keepers who were approached in the pilot study all referred to their cattle breed as simply “Borana” and could not detail the subtype. Thus, the categorisation of Borana subtypes to the respective areas was done on the basis of **phenotypic** expressions that were later on verified by scientists at the International Livestock Research Institute in Addis Ababa. Further research is definitely needed for defining exact subtypes of the Borana breed by analysing blood samples. Treating the subtypes as dummy variables in the economic analysis later on constitutes a crucial issue in this study, aiming to reveal whether this variable has impact on the taste of livestock-keepers for different cattle traits and facilitating the question of which subtype should be conserved.

Figure 3: Research area



4.1.3. Survey mode

In general, there are several **survey modes** one carefully has to choose from, bearing in mind that the kind of survey mode also affects the sample frame (Bateman et al., 2003, Chapter 3). In any case, in this study the decision about a survey mode was irrelevant because only **face-**

to-face interviews seemed to be feasible due to the lack of technical infrastructure and availability of means of communication. Face-to-face interviews have many benefits compared to other modes with greater anonymity such as telephone or mail surveys. Above all, face-to-face interviews minimise the survey error. These kinds of errors fall within the category of **measurement error**, defined as errors associated with inaccuracies in the responses recorded on the survey instruments (Bateman et al., 2003, Chapter 3). These errors can be due to either a) the effects of the enumerators on the respondents' answers to the survey questions, or b) to the respondents, arising from their inability to answer questions, or c) to weaknesses in the comprehensibility of the questionnaire and the experiment (wording, language, pictures in the choice sets etc.), or d) to effects of the mode of data collection. Secondly, face-to-face interviews positively affect the **quality of data collection**. Taken that the interviewers/enumerators have been carefully trained prior to the start of the survey and experienced, they can have positive impact on the respondents. With the interviewer's assistance, the researcher can attempt to obtain a more complete picture of what transpired during the course of the survey (Bateman et al., 2003). First of all, well trained enumerators can ensure that the correct member of the household responds to the survey (in this study it was always the **head of the household** to ensure the extraction of the maximum of information). They can assist and correct, motivate and monitor the respondents. Monitoring the respondent's behaviour on whether he/she seemed attentive, or thoughtful, or confident in his response to the choice tasks is very important. When the enumerators had the feeling that, although the experiment procedure was carefully explained beforehand, the respondent did not understand the CE and made arbitrary choices, the data set was not included in the analysis. However, this case was very rare.

4.1.4. Questionnaire design

The questionnaire consisted of four major parts. To begin with, a **semi-structured part** was used to elicit household data, data on animal characteristics, organizational aspects, livestock marketing aspects, and on the costs and revenues of keeping cattle in the research area. Secondly the **CE** was carried out, and thirdly livestock-keepers' **attitudes** towards cattle breeds and conservation initiatives were perceived using Likert scales[61]. The final part contained **CV,** looking at the WTA compensation for keeping pure Borana cattle (i.e. the large framed Ethiopian subtype (EB)). A detailed description of the CE is issued in the next

[61] Likert scales require respondents to indicate the degree of agreement or disagreement with a number of statements related to the status of Borana cattle.

section. The contingent valuation scenario will be discussed in Chapter 6 as it is part of the cost-analysis of the conservation of pure Borana cattle.

4.2. Choice experiment design and procedure

A CE is a 'structured method of data generation' (Hanley et al., 1998a), as it relies on carefully designed tasks or "experiments" to reveal the factors that influence choice. The purpose of **multiple** CE is to provide at least two design alternatives; choice sets in which they appear are designed in such a way that their effects can be significantly estimated (Louviere et al., 2000). The design of the entire experiment is as important as the interpretations of the results and hence this section carefully explains the experimental design (ED) and how it was performed in the field.

A key factor determining the **quality** of the CE's outcome relates to the success to which the animals in the choice sets can be meaningfully, accurately and consistently presented to the livestock-keepers. In the introduction of the CE, the experimental procedure was explained without any mention of the aim of the study: the conservation of the pure Borana breed. The study's underling hypothesis of a possible threat to the pure Borana breed was also not mentioned in order to avoid any **hypothetical bias**[62] (Bateman et al., 2003), possibly leading to incorrect valuations. Next, the **attributes** and **levels** were explained to the respondents using **pictorial images** that supported **verbal descriptions** of the animal profiles as survey **instrument**. The questionnaire, attributes and level used in the CE were developed according to a pilot study with several focus group discussions and in-depth interviews. The payment vehicle used in the CE was the market price of a five year old bull or cow, respectively. An example of the choice sets for bulls and cows can be found in the Appendix (Figure 11 and 12).

Several profiles were created, and are referred to as **animal profiles** in this study. Each animal profile represents one animal in terms of its attributes and levels of these attributes. The chosen attributes and levels will be described in Chapter 4.2.1. A certain combination of different animal profiles (referred to as **choice set**) was presented to livestock-keepers in the research area and they were asked **repeatedly** which animal profile they prefer among all given profiles in the choice set. The animal profiles were **unlabelled** and convey no information beyond that provided by their attributes (Louviere et al., 2000). That implies that

[62] Hypothetical bias usually occurs when actual WTP is less than stated WTP (Bateman et al., 2003). While some would dispute what we take as "actual" WTP (for example, if the mechanism used to elicit real payments encourages free riding), this weight of evidence leads to the uneasy feeling that CV estimates are biased upwards due to the hypothetical nature of the payment commitment.

no breed names were used to describe the animal profiles. This was because such an approach would rather lead to biased results as many livestock-keepers certainly choose according to a particular breed rather than to the attributes describing the presented breeds.

In order to fit within a discrete choice framework (and a MNL model), the choice sets need to exhibit three characteristics (Train, 2003, pp. 15). First, the alternatives must be **mutually exclusive** from the decision maker's perspective. Choosing one alternative necessarily implies not choosing any of the other alternatives so that the decision maker chooses only one alternative from the choice set. Second, the choice set must be **exhaustive**, in that all possible alternatives are included. The decision maker necessarily chooses one of the alternatives. Third, the number of alternatives must be **finite**, this means the researcher must be able to count all the alternatives. (Train, 2003). Bateman et al., (2003) suggest restricting the number of attributes chosen for the design to a relatively small number (such as 4, 5 or 6). This is because the minimum required sample size increases exponentially in the number of attributes. With a very large sample size a higher number is also feasible (Bateman et al., 2003). The number of levels for each characteristic within the profile should also not exceed five (Bateman et al., 2003).

In this study a **choice ranking** (CR) approach was preferred over a simple CE. In a CR approach, a sample of individuals is required to rank a discrete choice set of alternatives from their most to their least preferred. However, the model specifications are the same, only the experiment design, data entering and coding differ between the CE and a CR approaches (Louviere et al., 2000; see also Chapter 2.4.1.1). The advantage of a CR over a CE approach is that the CR approach provides more "choices" per respondent and therefore a **greater set of information** (Louviere et al., 2000; Bateman et al., 2003). A full ranking further provides information on the non-chosen alternatives (Hensher et al., 2005, p. 84).

Four choice sets for cows and three choice sets for bulls were presented to each respondent. Hence, each individual did **seven full rankings** between four animal profiles (options/alternatives) (Animal A, B, C or the "no-buy" option) and thereby made 7*3=21 choices[63]. 370 respondents account for a total amount of 7770 choices. The reason why respondents were presented with four choice sets for cows but only three for bulls was that for cows the selected levels and attributes give rise to a greater number of combinations (648 compared to 432 for bulls). Louviere et al. (2000, p. 103) makes the point that with increasing complexity of levels and attributes task complexity increases. This increasing complexity for

[63] The four alternatives/profiles in a choice set (animal A, animal B, animal C, "no-buy") give rise to three choices.

the choice sets for cows then gave rise to a greater number of observations in order to obtain reliable information.

4.2.1. Description of attributes employed in the choice sets

Each animal profile contained **seven attributes** and their levels, whereby the profiles for cows and bulls vary in two attributes, namely offspring (for bulls) and calving (for cows), and traction suitability (for bulls) and milk quantity (for cows). The remaining five attributes were the same for both sexes with price being adjusted for cows and bulls, based on authentic market prices. It is noteworthy that the prices in local currency were simply converted into Euros based on the **exchange rate** in May 2004: 1 Euro=80 KSH (Kenyan Shillings) and 1 Euro=10 Birr. In late 2004, however, with the rise of the Euro the exchange rates changed slightly and could be by this time different than the rates used for this study.

The chosen attributes and levels finally chosen for the animal profiles were as follows:

1) Big body size vs. small body size
2) Tick tolerance vs. no tolerance
3) Watering frequency: each day, after 2 days, after 3 days
4) Horn shape and size: short and straight, long and straight, long and curved
5) Traction suitability vs. unsuitability (bulls)
   Milk quantity: 0-2 litres, 2-4 litres, more than 4 litres (cows)
6) Strong offspring vs. weak offspring (bulls)
   One calf every year vs. one calf every two years (cows)
7) Market price: 90, 120, 150 € for bulls in Ethiopia and 100, 137.5, 175 € for bulls in Kenya; 40, 60, 80 € for cows in Ethiopia and 81.25, 112.5, 143.75 € in Kenya

Body size (binary variable; "big" = 1 for big body and -1 for small body)

Body size was explained to the respondents as either "leggy and with lengthy body" as a synonym for big-framed or as "short legged and rather stocky" meaning of small size.
An animal's body size is determined by two factors: environmental adaptation and its genetic condition. Hence, inferring from the body size to the breed is not always reliable because certain circumstances such as the occurrence of frequent and long lasting droughts can cause a decrease in body size in the next generation although the breed is usually known for a large frame. A big body size is usually preferred by livestock-keepers because it has several advantages: superior traction power (small animals cannot handle muddy fields), less prone to tick infestation (because with long legs the body has not that much contact to bushes where ticks usually hide), higher drought resistance, better walk ability (because of longer legs it can

cover longer distances) and, finally, greater cultural value. In any case, many livestock-keepers nowadays prefer small-framed animals over big ones because, according to them, big-sized animal also have some disadvantages, somehow contradictory to the above-mentioned advantages. The disadvantages evolve in cases of droughts and can be such as: higher mortality (due to larger absorptive surface and higher maintenance energy requirement), heavier body weight (interviewed livestock-keepers complained that big and heavy animals cannot be lifted up easily after having collapsed of weakness). It is safe to say that in "normal" times large-framed animals have many advantages and are preferable but livestock-keepers have long recognised their disadvantages in drought seasons and in this case often shift to smaller animals. Smaller cattle are also cheaper to purchase on the local markets and, after having lost a large number of animals due to some external shock (diseases, droughts etc.), livestock-keepers tend to restock their herds by rather buying many small and cheaper animals than larger and costly ones.

The numerous breeds in the research area can be categorized in small or big such as follows:

- Big-sized: Ethiopian Borana, Somali Borana, (Kenyan Borana), Gari
- Small-sized: Orma Borana, SEAZ, Guji

All exotic breeds and their crosses are commonly of a large frame while many Borana crosses posses a small frame due to the influence of the Guji breed (particularly in Ethiopia).

Tick tolerance (binary variable; "tick" = 1 for tolerant and -1 for not tolerant)

This trait is important as it affects the productivity, particularly in cows' milk yield. Ticks can reduce the walk ability and eventually cause death when the animal is so heavily infested that it cannot walk anymore. Ticks are responsible for the transmission of so called tick-borne diseases with some serious ones eventually being fatal (Ngugi et al., 1990). Death can also take place when ticks reach into the ears. Ticks are found in bushes and due to increasing bush encroachment tick infestation have become worse within the last 10 years. The parts of the body that are hit most severely are the belly, the udder, the head and ears. The Borana breed and especially the Ethiopian and Somali subtypes are said to be less prone to tick infestation than other local breeds and exotic breeds because they posses a particular skin surface with relatively longer hair where ticks easily slip down. Furthermore, as already mentioned, they are quite leggy and thus usually not so much affected by ticks. Livestock-keepers have long recognised the threat posed by tick infestation and, as a result, when they have the opportunity to, they regularly use acaricides in dipping, spraying or when they rub the animal's skins. This treatment is usually done every night after the herd has returned from the pastures and is often the children's responsibility. The medication against ticks is usually only accessible to livestock-keepers who live sedentarily with their herds so that the animals can be treated appropriately every night. That requires access to markets and veterinary services in the first place. Therefore, the treatment with acaricides is not widely applied among the pure pastoralist. In the past ticks control was simply carried out by the burning of old pastures and grass (Ngugi et al., 1990) but since fires were banned as common pasture management in 1974 (see Chapter 3.2.6), tick infestation increased with increased shrubs and bush encroachment (Coppock, 1994).

Watering frequency (numerous variable; "wat_1" = watering once a day, "wat_2" = watering once in two days, "wat_3" = watering once in three days)

Watering frequency reflects the ability to stay without water for a certain time period. This trait is among the most important ones, particularly with regard to the Borana lowlands. High productive breeds need water every day while local adaptive breeds are able to go without water for two days and a maximum of up to three days. This attribute differs between local breeds and, in general, it can be said that large-framed breeds are usually able to stay without water for three days while all others can survive two days without water. Livestock-keepers in the lowlands heavily rely on the fact that their cattle can stay without water for a certain time because they track the herd from watering point to watering point within this timeframe.

Horn size and shape (numerous variable; "horn_1" = short and upright, "horn_2 = short and curved, "horn_3" = long and curved)

This attribute is rather exceptional because it measures an intangible cultural value of cattle. Having a particular horn size and shape does not relate to direct measurable utility of animals. However, livestock-keepers nevertheless identify a certain non-use value with respect to horns. In some West African countries, for instance, cattle with long screwed (twisted) horns are known for their enormous cultural value (Ankole breed, a longhorned Sanga type (Payne and Hodges, 1997)) even though long horns often cause injuries. This is the reason why animals in intensive production systems are selected for being polled (=naturally hornless) or if horned become dehorned. In any case the Borana breed has a clearly defined horn size and shape, namely short horns that are thick at the base and thinner at top. The shape is commonly slightly curved inwards or might be upright. Long horns are usually larger than 12 cm and are slightly or heavily curved. In the research area the SEAZ in Kenya was the breed with the longest horns, followed by the Ethiopian Guji breed. The shortest horns were observed among the Somali Borana in the Burbisa district in Kenya. The attribute "horns" was included in the choice design in order to test whether livestock-keepers in the research area aim to achieve cultural recognition from keeping breeds with a particular horn shape and size. Figure 10 in the appendix gives an example of each of the three horn conditions.

Traction suitability (binary variable; "traction" = 1 for traction suitable and -1 for unsuitable)

Traction power is very important, particularly in developing countries where extensive production systems prevail and machinery is scarce. For pure pastoralists traction power is not important but with livestock-keepers shifting more and more to agriculture as a means of additional income and nutrition supplement, bulls are more frequently used for ploughing. Two bulls are required to pull the ploughs and it is very common in the lowlands to borrow and lend suitable bulls for traction among neighboring people. Sometimes reproduction bulls are also used for ploughing but, most commonly, the bulls used for draft power are castrated. There seems to be a positive relationship between the body size and the suitability for traction with larger animals being more suitable. The horns can also determine whether a bull is well suitable or not. Very long horns often disable the livestock-keeper to install the plough. The Borana bulls are reputed to be well suitable for traction.

Bull's offspring (binary variable; "offspr" = 1 for strong offspring and -1 for weak offspring)

This is an important economic factor in cattle production. Strong offspring are more likely to survive the first two years, especially in drought seasons. This variable was binary, either a bull is able to produce strong offspring or not. Strong was meant in the sense that the calves are big and stout and the parameter "offspring" is in general used as a measure for fertility. The Borana breed and specially the Ethiopian, Somali and Orma types are known for producing strong offspring and to be well active in reproduction behavior.

Calv*ing frequency (binary variable; "calf" = one calf per year and -1 for one calf every two years)*

Calving frequency describes the time interval between two births. It is also known as parturition interval, that is the interval, in days, for an individual female from one parturition to the next (Esslemont et al., 1985). The interval ranges between 400 to 500 days (for improved Kenyan Borana) and up to 3 years for local breeds such as the Orma Borana.

The pregnancy takes approximately 3 months, the time for a subsequent conception (=the time before a cow is successfully pregnant again) another six to nine months in an ideal case. In developed countries high yielding milking cows should calve at 9 to 12 months intervals. In the Borana lowlands it is possible to have one calf per cow per year. This is desirable in “normal” seasons when the likelihood is high that the calves survive. In droughts however, cows normally give birth to one calf every two years due to failed conception, miscarriages or stillbirth as a result of the drought and lack of water and fodder. The Borana cows are reputed for high fertility and hence good conception rates (=rate that is needed for a successful conception, number of trials for bulls) as well as for a decent motherbility (ILRI, 2006a).

Milk yield (numerous variable; milk_1 = less than 2 liters a day, milk_2 = 2 to 4 liters a day, milk_3 = more than 4 liters a day)

The milk yield is important for two reasons: firstly, for self-consumption and secondly, for selling on the market when the amount of milk exceeds the level of self-subsistence. Sometimes this is the only recurrent income apart from selling live animals. Milk is usually sold on the market only seven to nine months a year depending on availability and duration of the dry season. In dry seasons milk is not sold but kept almost entirely for the calves. Three levels of milk yield were employed: 0-2 liters, 2-4 liters and more than 4 liters. The Borana breed is known to give a yield little above the average amount of 2 liters, and rarely up to 4 or 5 liters. More than 4 or 5 liters however can only be achieved from improved crossbreeds and crosses of local with exotic breeds. The improved Borana breed of the Central Kenyan highlands achieves a daily milk yield of about 6 liters (ILRI, 2006a).

4.2.2. Theory of experimental design

At the beginning of this chapter, it was briefly explained how animal profiles were created based on prevailing important cattle attributes (traits). Two further crucial steps are then necessary: firstly, to decide on the **number of animal profiles** that eventually will be used in the CE and secondly, on the **combination of animal profiles** to a so-called choice set. The two procedures are most essential for the efficiency of the experimental design (ED) as shown in the following section. It is important to emphasise that with an **inefficient** choice design the results are likely to be biased and inconsistent.

4.2.2.1. Number of animal profiles

Given the number of attributes and the relevant levels, one can calculate the number of **possible combinations**. For the choice sets for cows with three attributes possessing two levels (calving interval, tick tolerance and body size) and four attributes possessing three level (horns, water frequency, milk yield and price) the number of all possible combinations amounts to $2^3 * 3^4 = 648$. For the design for bulls, the number of all combinations equal $2^4 * 3^3 = 432$ because the animal profiles for bulls consist of four attributes with two levels (traction suitability, offspring, tick tolerance and body size) and three attributes with three levels (horns, water frequency and price). As it is not feasible to conduct a survey using all of these combinations, one has to define which combinations will be used as animal profiles.

Statistical design theory is used to combine the levels of the attributes into a number of animal profiles to be presented to respondents. There are basically two state-of-the-art types of designs that can be used (Hensher et al., 1999): **complete (or full) factorial**[64] **designs** allowing the estimation of the full effects[65] of the attributes upon choices or **fractional factorial designs.** The latter designs are able to reduce the number of scenario combinations presented with a connected loss in estimating power, i.e. some or all of the interactions will not be detected (Louviere et al, 2000; Bateman et al., 2003). The term "interaction" is defined by Hensher et al. (2005, Chapter 5) as the impact attributes have on each other when acting in concert, like, for instance, the impact of a certain combination of the two attributes "body" size and "water frequency" on the choice of animal A, B or C. Interactions are not to be confused with the concept of correlation (in which case the movement in one variable is similar to the movement in a second variable).The fractional factorial design aims at investigating only the **main effects** and guaranteeing the identification of all taste parameters during estimation (Kuhfeld, 2003). By selecting the smallest **orthogonal** main-effects design from the complete factorial, the statistical properties of the most general member of the **logistic regression** family can be satisfied (Bateman et al., 2003). That was the main motivation for using an orthogonal design in the context of this research.

Orthogonality means that each of the variables has zero correlation with any of the others (Bateman et al., 2003). This has the practical effect that the influence of changes in any of the presented cattle attributes in an animal profile on the respondents' choices can be identified and measured. Orthogonality further ensures that the marginals (i.e., alternative-specific and/or generic parameters) are orthogonal within and between choice alternatives, which satisfies the necessary and sufficient conditions to estimate the parameters of a Mother Logit model (such as basic MNL models in accordance to Mc Fadden (1974)). Mother Logit models include "cross-effects" of attributes of one alternative in the utility function of a second alternative, thus allowing violations of the IID property of basic MNL models (Louviere and

[64] In factorial designs each level of each attribute is combined with every level of all other attributes (Louviere et al., 2000, p. 84).

[65] Full effects include the effects of each of the individual attributes presented ("main effects") and the extent to which behaviour is connected with variations in the combination of different attribute offered ("interactions") (Louviere et al., 2000, p. 91). A full factorial design hence captures the main and all the interaction effects independent from each other (Hensher et al., 2005, p. 117). Effects are defined as the impact of a particular (animal) profile on the choice of respondents for one profile (Hensher et al., 2005, Chapter 5).

Woodworth, 1983). Orthogonal designs therefore yield the great benefit of allowing an independent estimation of main effects and interactions (cross-attribute effects), which in turn allows one to relax the IID assumption in the basic MNL model derivation and permits estimation of more complex model forms (Hensher et al., 1999). Although orthogonal designs produce strongly biased estimates as proved by Carlsson and Martinsson (2003) (see also see Rose and Bliemer, 2004), this design is still the most commonly used in environmental economics. However, due to this reason, particularly in market research, applying orthogonal designs is now refrained from and other designs are being switched to, such as, for example, shifted designs (see Bunch et al., 1996), D_p-optimal (see Kuhfeld et al., 1994; Sándor and Wedel, 2001) or D_b-optimal (see Sándor and Wedel, 2001; Kessels et al., 2004) designs which all seem to be more efficient than orthogonal designs (see Chapter 4.2.2.3).

Using a complete factorial design, i.e. considering all 648 profiles for cows and all 432 profiles for bulls causes the origination of an impracticably large number of combinations to be evaluated and hence the statistical package SPSS was used in order to reduce the number of combinations (profiles). Moreover, in linear models, main effects account for 70 to 90 percent of explained variance[66] (Louviere et al., 2000, p. 94) and hence it was decided that, for the purpose of this study, using a fractional factorial design considering main effects plus a few two-way effects (automatically generated by SPSS) was sufficient. The design for this study was generated by following **fractional factorial orthogonal** design procedure in SPSS. The SPSS procedure thereby ensures in any case an orthogonal design (Hensher et al., 2005, p. 130). The smallest design available, that is one in which only main effects are included (Hensher et al., 2005, p. 129), was found in SPSS to be 16. However, the minimum number of profiles that SPSS should generate in light of the number of levels and attributes (and hence due to the degrees of freedom) used in this experiment was set to be **32.** The design of 32 profiles enables capturing **main effects plus two-way interaction**s. 32 animal profiles for bulls and likewise for cows were considered the appropriate amount because in many experiments found in literature so far, at least 32 profiles were employed successfully (Louviere et al., 2000, p. 103).

[66] 5 to 15 percent of explained variance is typically accounted for by two-way interactions and hence only very little variance remains and is accounted for by omitted effects (Louviere et al., 2000, p. 94). Bias in the estimates of cattle attributes is hence minimised.

4.2.2.2. Grouping of animal profiles

In a further step, the 32 animal profiles were then **randomly blocked** into three and the "no-buy" profile was then added to them. In a second stage the sets were approved while accounting for **no overlap** of profiles within one set. Further optimization was taken care of in terms of the levels of attributes of the three animal profiles in one choice set with the aim to achieve **maximal level diversity** within one choice set ("level balance"; see Hubner and Zwerina, 1996). According to the two authors, orthogonality designs together with level balance and minimal level overlap yield efficient designs. Finally, a combination of three animal profiles (animal A, animal B, animal C) as well as a fourth option, a so-called **opt-out option**[67]**,** were chosen and together can be considered a **choice set**.

4.2.2.3. Limitations of experimental design and further outlook

CE design faces some **limitations** due to various potential **biases** resulting from inappropriate ED. For instance, a choice model that ignores the problem of choice set generation by assuming that each individual chooses from the universal choice set may be seriously misspecified (Ben-Akiva and Boccata, 1995). Biased estimates of the weights on the attributes and hence incorrect valuations mainly occur if the choice design cannot detect factors influencing the livestock-keepers choices for the animals. A relatively easy way to improve the efficiency of EDs is based on the research by Hubner and Zwerina (1996), who developed design-generating algorithms called **relabelling** and **swapping.** Later on, Sándor and Wedel (2001) developed a third algorithm, the cycling for further improvement of the design efficiency. The two authors further demonstrated that choice designs that provide more efficient parameter estimates also improve predictive validity.

The main problem stems from the fact that efficient designs require knowledge of the values of the parameters. This is so because the information on the parameters provided by the design depends on the values of those parameters (Sándor and Wedel, 2002). Of course, these parameter values are unknown prior to conducting the experiment and thus researchers simply construct designs by assuming that the parameters are zero (Sándor and Wedel, 2002). However, parameters are often assumed to be nonzero but that accommodates a certain uncertainty. It has been sought to alleviate this uncertainty in recent market research studies. Pioneer work has been done specially, just to name a few, by Sándor and Wedel (2001, 2002), Kuhfeld (2003), Huber and Zwerina (1996) and Rose and Bliemer (2004). Constructing EDs

[67] The opt-out option is the same as not buying any of the presented animals but keeping the money.

with improved **efficiency** including this prior knowledge[68] has recently become more important with the purpose of easing questionnaires for market researchers (Sandor and Wedel, 2002). More efficient questionnaires enable the targeting of **fewer respondents** and fewer questions asked to one respondent and hence the quality of the information is likely to increase and at the same time the budget can be exploited more efficiently. Using prior knowledge also enables analysts to abandon the idea of strictly orthogonal designs but to allow capturing mixed effects and attribute interactions (besides the commonly used main and two-way interaction effect approaches) and therefore offering profiles that are more "realistic" and "congruent" (see Rose and Bliemer, 2004). However, it is safe to say that the development of designs for CE is still in its infancy, and further research is needed to fully illuminate properties of designs and develop optimally efficient designs (Bateman et al., 2003; Carson et al., 1994).

For the purpose of this study, bearing in mind that the CE has been conducted in two developing countries where survey methods such as telephone or mail surveys are not feasible, the ED was derived in a rather simple way, following the dominant approach in environmental economics and evaluation case studies: the **fractional factorial for main effects with orthogonality.**

4.2.3. Coding and opt-out options

The introduction of an **opt-out alternative** (i.e. livestock-keepers chose this options when they did not approve any of the presented animal profiles but chose to keep the money instead) was necessary for the estimated welfare measures results to be **consistent** with demand theory. Bateman et al. (2003) make the point that "it is necessary to include a status quo option in the choice set in order to achieve welfare measures that are consistent with demand theory". This is, because, if a **status quo** (also termed baseline situation) alternative is not included in the choice set, respondents are effectively being "forced" to choose one of the alternatives presented, which they may not desire at all and that is inconsistent with demand theory (Bateman et al., 2003; Adamowicz and Boxall, 2001, Bennett and Blamey, 2001). Moreover, the use of status quo attributes allows the estimation of absolute values (Rolfe et al., 2000). If, for some livestock-keepers, the most preferred option is the current status quo situation, then any model based on a design in which the status quo is not present will yield inaccurate estimates of consumer welfare.

[68] Incorporating prior knowledge on probabilities of parameters requires data gathering in at least two phases. First, some CE are conducted and based on their results the ED can be improved for the usage in the second phase.

The **dependent variable** “choice” is a discrete variable that equals 1 when an animal profile is chosen and 0 if it is not. **Price** is the only **continuous** variable, taking on three levels which reflect true market prices and are adjusted for male and female animals. Continuous variables can simply be entered in their own units as continuous and marginal utilities can be easily interpreted later on (Bateman et al., 2003, Chapter 7). All attributes that take only two values (the **binary** attributes such as, for instance, being tick tolerant or not) were set up as -1/1 dummies. These variables were coded -1 for the non-expression of the attribute and 1 for the presence of the attribute. “Marginal” utilities here are interpreted as the difference in utility in going from a tick tolerant animal to a non-tolerant animal. In case of binary variables and the continuous price variable, the “no-buy” or “opt-out” option can function as the status quo option. The “no-buy” option is thereby coded with all attributes being **zero**.

When there is no continuous scale but more than two levels are specified, as is the case for “watering frequency”, “milk yield” and “horns”, “**effects coding**” is used (Bateman et al., 2003, Chapter 7, Hensher et al., 2005, Chapter 5). For these three attributes with three levels[69] the status quo options are then: for milk yield “2-4 litres”, for horn appearance “short and curved” and for watering frequency “watering once in two days”. “Effects coding” creates (n-1) dummy variables, where *n* is the number of levels. In the watering frequency case, two (3-1) variables would thus be created: “wat_1” and “wat_3”. Each one would signify a choice occasion with the requisite value. For the horn appearance, two attributes. “Horn_1” and “horn_3” are included in the choice sets and similarly for the milk yield “milk_1” and “milk_3”. The marginal utilities now become the extra utility from moving from the excluded case, also referred to as status quo option, (e.g. “wat_2”: watering once in two days) to either of the included cases.

4.3. Socio-economic differences among Borana livestock-keepers in Ethiopia and Kenya

The results of the household survey that was carried out simultaneously with the CE are emphasised in Table 6. The household characteristics are of importance later on in the MXL model analysis for revealing whether the differences among livestock-keepers have any impact on the choice for one animal or the other. The results of the household characteristics were derived from descriptive statistics.

[69] Including all three levels of these attributes would result in a collinearity problem and the estimation of the MNL model would be infeasible.

Table 6: Socio-economic characteristics across respondents (St. Deviations in parenthesis)

	Ethiopia		Kenya		all	
Sex (in %)						
Male	93.5		98.4		95.1	
Female	6.5		1.6		4.9	
Age (in years)						
Mean	45.3 (15.7)		50.9 (13.4)		47.3 (15.1)	
Household size (in head)						
Mean	6.0 (2.6)		6.1 (1.7)		6.0 (2.3)	
Number of children under 15 yrs. (in head)						
Mean	3.2 (1.8)		2.7 (1.6)		3.0 (1.8)	
Aba Ola (village chief) (in %)						
Yes	10.6		7.3		9.5	
No	89.4		92.7		90.5	
Highest level of education (in %)						
	HHH	*Child*	*HHH*	*Child*	*HHH*	*Child*
Illiterate	86.6	54.1	*87.9*	*21.8*	87.0	43.2
Can write and read	9.8	39.4	*9.7*	*53.2*	9.7	44.1
Completed primary school	0.8	2.4	*1.6*	*9.7*	1.1	4.9
Secondary school	2.8	3.3	*0.8*	*13.7*	2.2	6.8
Completed secondary school	0.0	0.8	*0.0*	*1.6*	0.0	1.1
Household income from cattle products (in Euros)						
Mean	73.4 (183.0)		84.4 (401.2)		76.2 (276.1)	
Number of animals (in head)						
Cattle	17.7 (16.1)		19.6 (21.6)		18.4 (18.2)	
Cows	9.2 (10.6)		10.5 (12.0)		9.6 (11.1)	
Bulls	2.5 (2.8)		3.9 (4.2)		3.0 (3.4)	
Calves	6.1 (5.1)		5.4 (7.9)		5.9 (6.2)	
Goats	4.3 (5.2)		15.4 (25.7)		8.0 (16.3)	
Camels	1.2 (2.4)		2.0 (3.9)		1.5 (3.0)	
Production system (in %)						
Crop production	1.6		0.0		1.1	
Agro-pastoralist	81.3		40.3		67.6	
Pastoralist	17.1		59.7		31.4	
Movement (in %)						
	Cattle	*Family*	*Cattle*	*Family*	*Cattle*	*Family*
Sedentary	13.8	88.2	*3.2*	*99.2*	32.8	91.9
Transhumant	30.5	11.4	*37.1*	*0.0*	10.3	7.6
Nomadic	55.7	0.4	*59.7*	*0.8*	56.9	0.5

4.4. Summary

The main purpose of this chapter was to describe how the survey was conducted, in terms of sampling strategy, sample size and distribution. The conducted survey mainly embraced two elements. First of all, a semi-structured questionnaire was used to elicit household data, and secondly a CE was carried out. Equally important to the sampling procedure for the interviews is the procedure of designing the CE because poorly designed experiments lead to bias and incorrect results.

This chapter thoroughly described the cattle attributes that were considered for the choice sets, and explained how the choice sets were created bearing in mind some assumptions and constraints for efficient choice design. Eventually, seven attributes were included, and their combination in light of different levels reflected one “animal profile”. The profiles are unlabelled. Giving the number of totally possible combinations, only a fraction, namely 32 animal profiles were selected for the use in the experiments. This design of 32 profiles was generated by following fractional factorial orthogonal design procedure in SPSS, enabling capturing main effects plus two-way interactions. Three animal profiles at a time were blocked into one choice set. Beside the three animal profiles, one opt-out option was integrated in the choice set allowing respondents not to select any presented animal profile but in theory to keep the money and do nothing. Finally, it was explained how the data derived from the CE was coded using “effects-coding” and in case of binary attributes -1/1 coding, signifying absence (-1) or presence (1) of one attribute expression. This chapter concludes with information on socio-economic differences between Kenyan and Ethiopian livestock-keepers.

CHAPTER FIVE

The value of cattle attributes and breeds in East Africa

5. The value of cattle attributes and breeds in East Africa

Chapter 5 can be broken down into two parts, each presenting different sets of results: the first set of results (Chapter 5.2) focuses on the monetary assessment of **single cattle attributes** while the second set of results enables the bridging of the gap between the economic valuation of attributes and the economic valuation of different **cattle breeds** *per se* (Chapter 5.3). The monetary evaluation of the two factors, cattle traits and breeds, leads to some important policy implications as detailed in the last section of this chapter (Chapter 5.4). Prior to the results, however, the reason why the valuation of cattle and their attributes bore manifold difficulties related to market failures and why different models were chosen will be explained.

The objective of assessing the various values under different perspectives is twofold: first of all, to provide **justification for conserving** the Borana breed and its subtypes, and secondly, to provide a better understanding of their **breeding value**.

As explained in Chapter 2.2, the CE assesses the use-values of important cattle attributes and breeds as perceived by local livestock-keepers.

5.1. The value of single cattle attributes

This first part presents results of the MNL as well as of the MXL model. Both models aim at assessing the WTP for single attributes (see Chapter 2.3). Each of the two models has a **different purpose**. The MNL model is particularly relevant when knowledge of a good *per se* on the one hand, and its attributes, on the other hand, are vital from a policy point of view. On the contrary, the MXL model and accounting for preference heterogeneity is important in cases where assessing the potential of and costs for conservation programs for AnGRs is vital. However, both models quantify the values of attributes and thereby also the **breeding values** of cattle that possess these attributes. The monetary value of attributes can simply be taken as their distinctive values helping breeders to define breeding goals. Breeding schemes could then also aim at breeds that possess certain attributes of great monetary value even if the breed would usually not attract interest to breeders.

All estimates were obtained with LIMDEP 8.0 Nlogit 3 by Econometric Software Inc (Greene, 2003b). Different data sets were educed as the basis for the two models. The basic MNL model was used, above all, for the pooled data set and secondly, for the country-specific data sets whereas the MXL model was only applied on the pooled data set. The pooled data set was quasi exposed to two steps: first of all, the basic MNL was estimated and secondly, all animal attributes with significant parameter estimates in the MNL were assumed to vary independently according to normal distributions and a (panel) MXL model was estimated assuming a normal distribution. In the MXL model taste heterogeneity among respondents was explicitly treated and hence permitted seeing whether there were differences in the choice for attributes among individuals with different socio-economic background, including the type of production system and household data.

5.1.1. Results of the basic MNL model

The basic MNL model was used to identify a number of attributes which either increase or decrease the **utility** derived from a cow and a bull and to shed light on the livestock-keepers' WTP for these attributes. As a first step, the data was explored using the basic MNL model whereby the data was split up into two **country-specific sets** (Kenya and Ethiopia data sets) which were analysed along with the **pooled set** including data of the entire sample. This procedure provided a first outline of the data, seeing whether all coefficients of attributes were according to expectations. This method is not to be confused with the MXL model which will be applied later on. The MNL model, even when applied on country-specific data sets, always assumes fixed taste parameters (see Chapter 2.4.1).

5.1.1.1. The best model fit

Testing the significance of attributes for the choice decision is done by applying a log-likelihood ratio test for comparing models with different number of variables (in this case different number of cattle attributes). The test statistic is asymptotically distributed as χ^2 and is expressed as:

$$\chi^2 = -2(LL_1 - LL_2) \qquad (14)$$

where LL_x refers to the log likelihood statistics for the different models with different set of variables. The test statistic was explained in more detail in Chapter 2.4.1.3.

The highest value of the log-likelihood function is found for the specification with all attributes entering the model in a strict linear distribution. The indirect utility function V (for individual i choosing animal profile j) entering the MNL model for bulls and cows can hence be written as follows:

$$V_{ij} = \beta_1(Z_{price}) + \beta_2(Z_{adaptability}) + \beta_3(Z_{production}) + \beta_4(Z_{culture}) \qquad (15)$$

where β_{1-4} refers to the vector of coefficients associated with the vector of attributes describing cattle. Price is the important monetary value used later on for deriving welfare measurements, “adaptability” is broken down into “watering frequency” and “tick tolerance”; “production” is subdivided into “condition of offspring” (for bulls), “calving frequency” (for cows”, and “daily milk yield” (for cows), and “traction power” (for bulls) and finally, the attributes for “culture” consist of “horn size and shape” and “body size”. It is worth mentioning that because of the unlabeled, and treated as generic, parameters of this CE, it makes no sense to introduce an alternative specific constant (ASC) (Hensher et al., 2005, p. 371). However, introducing one constant for all alternatives might be reasonable but. in light of this study, in doing so the overall model fit decreased and it was concluded that the best utility function is one without constants. The interpretation of such a constant is often unclear and, despite all other considerations, not straightforward.

Three different measures were applied in this study in order to derive **optimal models** for each of the data sets for cows and for bulls. First of all, a Hausman test was conducted aiming to ensure **no violation of the IIA** assumption (see Chapter 2.4.1.2). Secondly, the ρ^2 value, indicating the overall **model fit** (see Chapter 2.4.1.3) was calculated, and thirdly, it was tested whether it was better to treat the data sets for Kenya and Ethiopia as separate **country-specific models**.

It was found that the IIA property is not violated implying that the MNL estimates do not hold any bias. This potential bias could have particularly resulted from inclusion of the ‘buy no animal’ option. Furthermore, the ρ^2 values indicate good fits particularly with respect to the cow model (see Table 7 and 8). The p-values[70] for the χ^2 statistic for both models are 0.0000 which is less than the level of acceptance (α) of 0.05 (at a 95 percent confidence level). Hence, both models are statistically significant overall.

Respondents in different research areas may face different trade-offs in cattle production, and capturing of these differences, should they exist, may have relevant consequences in efficient policy design for conservation initiatives. It is therefore crucial to investigate whether and in which direction the country-specific characteristics, such as market integration or agro-ecological conditions, affect livestock-keepers’ demand for cattle and for their attributes. Hence, whether or not the set of parameter estimates of the pooled model are shared across

[70] P-value is short for probability value and sometimes also refereed to as significant value (Hensher et al., 2005, p. 336).

the two countries must be tested. Consequently, separate MNL estimates were obtained for Kenya and Ethiopia and the likelihood ratio test under the following hypothesis was tested:

$$H_0 : \beta_{pool} = \beta_{Kenya} = \beta_{Ethiopia} \qquad (16)$$

where β_x are the MNL parameter vectors. Rejection of the null-hypothesis would imply that livestock-keepers in different countries have different demand models for cattle attributes. The log likelihood ratio test rejects the null hypothesis that the regression parameters for the two country-specific bull models are equal because $\chi^2 = -2(-2467.4 + 808.8 + 1650.5) = 16.2$, which is larger than 15.5, the critical value of chi square distribution at 8 degrees of freedom[71] at 0.5 percent significance. In other words, the valuation of cattle attributes varies significantly between the two country-specific samples. Likewise, comparison of demand estimates for cows in Kenya vs. Ethiopia is $\chi^2 = -2(-3582.9 + 1186.0 + 2349.5) = 94.8$ which is also larger than 16.9, the critical value of chi square distribution at 9 degrees of freedom at 0.5 percent significance. It can therefore be concluded that livestock-keepers have **distinct preferences** for cows as well as for bulls and their attributes in each of the two countries compared to the attributes in the pool.

As presented in Table 7 and 8, in the model for the **pooled data** all cattle attributes show significance for **bulls,** i.e. all seem to have an impact on the purchase behaviour of livestock-keepers for cattle. For **cows**, all attributes but the "horn size and shape" contribute significantly to livestock-keepers' choice concerning the purchase of cows. A model where the two attributes describing the horns (variables "horn_1" and "horn_3") is dismissed fits much better than the initial model including all cow attributes[72]. Moreover, in almost all cases for cows and bulls, coefficient signs of attributes were in accord with a priori **expectations**. A negative coefficient signifies that livestock-keepers derive a **negative utility** from the attribute and prefer animals without them. Attributes showing positive coefficients are liked by livestock-keepers as they associate a **positive utility** from them. The coefficient for **price**

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[71] The number of degrees of freedom amounts to (n-1), whereby n stands for the number of attributes in the model (bulls: 9 attributes, cows: 10 attributes).

[72] Conducting a log-likelihood ratio test verified that the model fit is better when the two attributes "short and straight horns" and "long and curved horns" in a stepwise top-down approach was omitted. Firstly, removing the attribute "short and straight horns" from the model gives a test statistic of LK=-2(-3333.88+3332.12)=3.50 that is lower than the critical value of χ^2 distribution of 3.84 at 1 degree of freedom (d.f.). Removing the second insignificant attribute "long and curved horns" generates a test statistic of LK=-2(-3335.79+3333.88)=3.82, which was slightly smaller than the critical value of χ^2 distribution of 3.84 at 1 d.f. at 0.5% significance. According to the stepwise exclusion, both attributes on the condition of horns can be dismissed without reducing the model's fit.

is negative, as are the coefficients for bulls for "small and straight horns" and "long and curved horns" relative to the status quo "short and curved horns". The coefficient for the attribute "water frequency once a day" also exhibits a negative coefficient for the cow and the bull model, signifying that utility of animals needing water every day is less than that of animals needing water only once in two days (the status quo option) and of animals needing water only once in three days. In the cow model, daily milk yields of "more than 4 litres" and "0 to 2 litres" cause less utility than "2 to 4 litres". All other attributes posses positive coefficients, i.e. traction suitability is preferred over unsuitability, big sized animals are preferred over small ones, strong offspring are preferred over weak offspring (for bulls), annual calving frequency is preferred over biannual frequency (for cows), a water frequency of "once in 3 days" is preferred over a water frequency of "once in 2 days".

In the case of the **country-specific** models, it came to light that in Ethiopia and Kenya not all attributes seem to have a significant impact on the purchase behaviour. Hence, dismissing some of the insignificant attributes from the model needs to be considered in order to clarify whether they really have no significant impact on the livestock-keepers' choices for cattle and to improve the overall model fit. The log-likelihood ratio test was applied to test whether these insignificant attributes were eligible for omission from the models[73]. After revealing insignificant attributes in the models, these attributes were stepwise dismissed from the model in order to improve its fit (=**top-down approach)**. Tables 7 and 8 display the coefficients of the final bull and the cow model, for Kenya, for Ethiopia and the pooled sample. Similarly for the pooled model, all country-specific models showed p-values of 0.0000 for the χ^2 statistic and thus were statistically significant overall at a 95 percent confidence level.

In the **Kenyan bull model**, for instance, three attributes show insignificant p-values, namely "body size", and "short and straight horns" and "long and curved horns" signifying that there is no difference in utility from these two horn conditions to the status quo of "short and curved horns" that is the common horn shape for Borana cattle[74]. It can hence be stated that horns are not at all important for the purchase decision of Kenyan livestock-keepers for adult bulls. The insignificance of the attribute "body size" is surprising, meaning that the size does

[73] The null hypothesis in this case tests whether certain attribute estimates are significantly different from zero, i.e. whether they influence the livestock-keepers' choice for cattle. If included new estimates are not significantly different from zero (in a down to top approach, i.e. starting with a few cattle attributes and continuing of adding others into the model) they cannot be omitted. Vice versa, if in a top down approach in which the unrestricted (the initial or base) model is the one including all attributes the estimates of dismissed parameters are not significantly different from zero, they should be omitted in order to increase the goodness of model fit. The test statistic was described in detail in Chapter 2.4.1.3.

[74] LR=-2(-809.14+808.83)=0.62, which is smaller than 7.81 the critical value of χ^2 distribution at 3 d.f. at 0.5% significance.

not influence purchase decisions for bulls and that Kenyan livestock-keepers assign the same utility to small-framed bulls as to larger bulls (all other attributes remaining equal and taken that the bulls were already mature at the time of purchasing).

On the contrary, livestock-keepers in **Ethiopia** assign significant relevance to the purchase decisions to all given attributes presented in the animal profiles for bulls and thus all attributes were kept as variables in the model.

Table 7: MNL model results for bulls

	Ethiopia		Kenya		all	
Attribute	**Coefficient**	**p-value**	**Coefficient**	**p-value**	**Coefficient**	**p-value**
Price	-0.011	0.0000	-0.011	0.0000	-0.011	0.0000
Watering every day	-0.673	0.0000	-0.654	0.0000	-0.665	0.0000
Watering once in 3 days	0.133	0.0021	0.147	0.0141	0.129	0.0002
Tick tolerance	0.296	0.0000	0.188	0.0000	0.263	0.0000
Big body size	0.095	0.0066	Not significant		0.069	0.0159
Strong offspring	0.189	0.0000	0.264	0.0000	0.223	0.0000
Traction suitability	0.549	0.0000	0.430	0.0000	0.511	0.0000
Short and straight horns	-0.096	0.0313	Not significant		-0.077	0.0334
Long and curved horns	-0.160	0.0002	Not significant		-0.129	0.0000
Log likelihood	-1650.5		-808.8		-2467.4	
ρ^2	0.45		0.47		0.46	

All values are significant at the 95% confidence level

The log-likelihood ratio test revealed that for **cows in Ethiopia**, three attributes have no significant impact on choosing one animal over the other, namely the attributes: “short and straight horns”, “milk yield of 0-2 litres a day” and “milk yield of more than 4 litres a day”. In other words, livestock-keepers in Ethiopia appear to be indifferent to the **daily milk yield**, i.e. the utility that they would derive from a cow is the same whether it gave “0 to 2 litres”, “2 to 4 litres” or “more than 4 litres” milk per day. Furthermore, Ethiopian livestock-keepers reveal indifference towards the **shape of horns** in cows. They in fact derive no utility difference from cows that have “short and short horns” or the status quo “short und curved” horns, but they assign different utilities for cows with “long and curved” horns, i.e. only the **size of the horns** had significant impact on the choice. These three insignificant attributes were then dropped from the model because the null hypothesis that the omitted attributes have no impact on the model cannot be rejected[75].

[75] LR=-2(-2163.86+2163.37)=0.98 which is smaller than 7.81 the critical value of $\chi 2$ distribution at 3 d.f. at 0.5% significance. Note that the number of degrees of freedom equals the number of restrictions.

Table 8: MNL model results for cows

	Ethiopia		Kenya		all	
Attribute	**Coefficient**	**p-value**	**Coefficient**	**p-value**	**Coefficient**	**p-value**
Price	-0.025	0.0000	-0.016	0.0000	-0.019	0.0000
Watering every day	-0.807	0.0000	-0.658	0.0000	-0.756	0.0000
Watering once in 3 days	0.275	0.0000	0.142	0.0108	0.171	0.0000
Tick tolerance	0.410	0.0000	0.296	0.0000	0.312	0.0000
Big body size	0.120	0.0005	0.105	0.0194	0.154	0.0000
Calving every year	0.411	0.0000	0.143	0.0011	0.326	0.0000
0-2 litres daily milk yield	Not significant		-0.319	0.0000	-0.240	0.0000
> 4 litres daily milk yield	Not significant		Not significant		-0.107	0.0004
Short and straight horns	Not significant		Not significant		Not significant	
Long and curved horns	-0.128	0.0001	Not significant		Not significant	
Log likelihood	-2163.9		-1125.0		-3335.8	
ρ^2	0.47		0.45		0.46	

All values are significant at the 95% confidence level

Kenyan livestock-keepers do not seem to relate their choice for **cows** on three attributes: “daily milk yield of more than 4 litres”, “short and straight horns” and “long and curved horns”[76]. They do not prefer cows which gave less than two litres per day (this attribute shows a negative coefficient) but at the same time did not derive higher or lower utility from cows which gave “more than 4 litres” than “2 to 4 litres” daily. Livestock-keepers in Kenya derive no higher or lower utility from cows with “straight and short” horns and “long and curved horns” than from the status quo alternative “short and curved horns”, i.e. they are entirely indifferent towards the cultural attribute “horns”, not only for cows but as mentioned above, but also for bulls. The horn appearance relates to the cultural value of an animal and its breed (for local livestock-keepers, the phenotypic appearance is the only way to tell whether an animal is of a certain breed and region). The Borana breed, for instance, is well known for its short and slightly inwards curved horns while breeds from the highlands often possess very long horns. However, Kenyan livestock-keepers do not define their utility for cows and bulls according to the attribute “horn size and shape”.

5.1.1.2. WTP for different cattle attributes

Once the parameter estimates have been obtained from a MNL model, a **WTP welfare measure** for a policy change that impacts on the good in question which goes along with demand theory can be derived (Hanemann, 1984). With one attribute being **price**, the **marginal utility of income** (= WTP for a change in any attribute), **ceteris paribus**, can be calculated. Hence, for any utility change induced by a change in cattle attributes, one can calculate the money payment that would induce the same utility change. This money payment

[76] LR=-2(-1125.08+1121.98)=6.20, which is smaller than 7.81 the critical value of chi square distribution at 3 degrees of freedom at 0.5% significance.

is the individual's WTP for getting one desirable cattle attribute (Rolfe et al., 2000). It is most convenient that the MNL model assumes a **linear** form of the utility function because due to this the calculation of the marginal utility of money can be simplified to the **ratio of coefficients** of the attributes in question $\beta_{attribute}$ and the coefficient of the monetary variable β_{money} (Bateman et al., 2003):

$$W = \frac{-\beta_{attribute}}{\beta_{money}} \qquad (17)$$

Table 9 and 10 describe the implicit prices[77] estimated from the logit model results in Table 7 and 8. These implicit prices show the "marginal" WTP on average of moving from one level - the excluded level or status quo level - to anther level, i.e. of moving from purchasing an animal with a certain desirable attribute to an animal without it or *vice versa*.

For the **pooled model** for **bulls,** the highest WTP can be seen for traction suitable animals (€47); the highest negative value is placed on animals that need water every day (-€62). All WTP values are "**ceteris paribus**" values, so they are only valid when all other attributed remain equal. The value of €47 for "traction suitability" means that people are on average willing to pay €47 extra per animal to move from a bull that is unsuitable for traction to a bull that expresses traction suitability. Furthermore, positive utility (that is a positive WTP) can be derived for "watering once in three days" (€12), tick tolerant animals (€24), a big body size (€6), and the production of strong offspring (€21). The two attributes associated with horn shape and size mean negative utility to the livestock-keepers (and hence rather a cost than a benefit). It can be stated, though, that the status quo attribute for "horns", namely the presence of "curved and short horns" contributes the highest benefit to livestock-keepers.

In the pooled model for **cows**, livestock-keepers show the highest WTP for an annual calving frequency (€17), followed by tick tolerant cows (€16). The attribute "water requirement once in three days" also contributed to livestock-keepers benefits (WTP of €9 per cow) as well as the attribute "big body size" with a WTP as high for bulls for the same attribute (€8). Obviously, for three attributes that were presented in the animal profiles, livestock-keepers derive no benefits at all; to the contrary, they have costs when they keep cows expressing these attributes. That is true for "watering once a day" (-€39), "0 to 2 litres daily milk yield" (-€12), and "more than 4 litres daily milk yield" (-€6). The trait "milk yield" consists of three levels and the status quo option is the most preferred one with the two other levels showing a

[77] Implicit prices are also termed marginal utility of income.

negative utility. In other words, livestock-keepers prefer a daily milk yield between two and four litres.

Exploring the **country-specific** data sets, the value of €49 for "traction suitability" constitutes the highest value, livestock-keepers are willing to pay for an attribute for **bulls** and this value is almost identical to the WTP value in the pooled data set (€47). The magnitude of the WTP for the attribute “watering once in 3 days” is approximately the same in both countries (€12 in Ethiopia and €13 in Kenya) whereas the attribute “strong offspring” is more highly appreciated in Kenya than in Ethiopia (€24 and €17, resp.). The same applies for the attribute “traction suitability”. In Kenya, livestock-keepers are only willing to pay €39 more for animals that expressed this trait, and hence €10 less than Ethiopian livestock-keepers would be willing to pay for the same trait. Further, the two country-specific models for bulls show different results with respect to the attributes “body size”, “short and straight horns” and “long and curved horns” as these attributes all possess insignificant coefficients in the Kenyan model and it can be inferred that Kenyan livestock-keepers, unlike Ethiopian livestock-keepers, do not place importance on these three traits when purchasing adult bulls.

The highest benefits in terms of **cow** attributes stems from keeping tick tolerant cows. In both countries this trait is assessed as highly important (in Ethiopia the WTP for tick tolerant cows amounts to €16, in Kenya to €18). Obtaining one calf per year seem to be more important in Ethiopia than in Kenya as the WTP for this attribute is two times higher in Ethiopia as in Kenya (€16 and €9, resp.). The ability to withstand water shortage for up to three days is similarly appreciated among Ethiopian and Kenyan livestock-keepers who are willing to pay €11 and €9 respectively per cow with this trait. Only livestock-keepers who reside in Kenya express significant preference (although in a negative term) for the productive attribute “0-2 litres daily milk yield” (-€20). That implies that Kenyan livestock-keepers were not at all satisfied with a low milk yield of 0-2 litres per day per cow, while Ethiopian livestock-keepers did not place any significance on the milk productivity of cows. They are indifferent about obtaining “0-2 litres”, “2-4 litres” or “>4 litres daily milk yield” per cow. Thus, an absolute value for the WTP cannot be calculated. This difference in the WTP indicators shows that productivity in cows seems to play a more important role in Kenya than in Ethiopia.

Table 9: WTP indicators for bulls' attributes (in €)

	Ethiopia		Kenya		all	
Attribute	**Coefficient**	**p-value**	**Coefficient**	**p-value**	**Coefficient**	**p-value**
Watering every day	-60	0.0000	-36	0.0000	-62	0.0000
Watering once in 3 days	12	0.0014	13	0.0121	12	0.0001
Tick tolerance	27	0.0000	17	0.0013	24	0.0165
Big body size	8	0.0069	Not significant		6	0.0000
Strong offspring	17	0.0000	24	0.0000	21	0.0000
Traction suitability	49	0.0000	39	0.0000	47	0.0000
Short and straight horns	-9	0.0378	Not significant		-7	0.0375
Long and curved horns	-14	0.0005	Not significant		-12	0.0005
CS	223		259		239	

All values are significant at the 95% confidence level

Livestock-keepers in Ethiopia, on the other hand, derive a negative utility from cows with "long and curved horns" (-€5) while respondents in Kenya exhibit insignificant preference for the entire horn appearance. A big body size of cows is preferred to small and stocky animals in both countries and this preference is expressed by a WTP of €6 from Kenyan livestock-keepers and €5 from Ethiopian livestock-keepers. The WTP measure for the attribute "water frequency once a day" is negatively perceived in both countries (-€32 in Ethiopia and even -€40 in Kenya).

Table 10: WTP indicators for cows' attributes (in €)

	Ethiopia		Kenya		All	
Attribute	**Coefficient**	**p-value**	**Coefficient**	**p-value**	**Coefficient**	**p-value**
Watering every day	-32	0.0000	-40	0.0000	-39	0.0000
Watering once in 3 days	11	0.0000	9	0.0093	9	0.0000
Tick tolerance	16	0.0000	18	0.0000	16	0.0000
Big body size	5	0.0005	6	0.0208	8	0.0000
Calving every year	16	0.0000	9	0.0012	17	0.0000
0-2 litres daily milk yield	Not significant		-20	0.0000	-12	0.0000
> 4 litres daily milk yield	Not significant		Not significant		-6	0.0006
Short and straight horns	Not significant		Not significant		Not significant	
Long and curved horns	-5	0.0001	Not significant		Not significant	
CS	101		170		134	

All values are significant at the 95% confidence level

5.1.1.3. Welfare gains for households

It is not only important to reveal the values for different cattle attributes but also to quantify the value that each livestock-keeper (and each household) derived from one cow or one cattle. These values are not the same as market prices but they can be seen as the value of the bundle of attributes as chosen in the CE. The value for the bundle, i.e. for one animal *per se*, is entirely hypothetical and only includes the attributes that were presented in the animal profiles. Certainly, the "real" market price included other attributes or external factors that cannot be captured with the CE.

The IV or log sum[78] for the discrete choice model can be written as:

$$IV_t = \log \sum_j \exp(\beta' x_j) \qquad (18)$$

That is the log of the denominator of the choice probability (see Equation (6) in Chapter 2.4.1.) and, according to Train (2003), the calculation of the expected CS in a logit model is based on this formula. Each observation has one IV, so the same value is stored for every choice for every individual. Hence, as livestock-keepers made three choices for bulls, three separated IVs are calculated for them, and four IVs for cows, respectively. The values indicated in Table 11 are mean values of all seven IVs of all individuals. Multiplying the calculated log-sum by the number of choices (observations) (in the pooled model, for instance: cows=4416; bulls=3276), the welfare gain for the whole sample can be calculated and by further dividing this number by the amount of households (in the pooled model: cows=368; bulls=364), the welfare gain for each household can be calculated. The results are shown in the subsequent table.

Table 11: Consumer surplus per individual and per household

	Ethiopia		Kenya		all	
	Bulls	**Cows**	**Bulls**	**Cows**	**Bulls**	**Cows**
CS of one adult animal in €	223	101	259	170	239	134
CS per household in €	2007	1215	2331	2041	2151	1611

The results clearly show that livestock-keepers in Kenya have a much higher CS from one cow than Ethiopian livestock-keepers (€170 to €101) whereas the CS from bulls are almost alike (in Ethiopia €223, in Kenya €259). With respect to the whole sample size (the pooled data set), it can be seen that the welfare gain from one adult bull exceeds the CS from one adult cow by almost double the amount (€239 to €134). Further, it is noteworthy that the CS of €134 for cows is higher than the prices given as levels in the animal profiles (on average €60 in Ethiopia and €112.5 in Kenya). In the case of bulls, the suggested market price in the animal profiles were on average €137.5 in Kenya and €120 in Ethiopia; investigation of the results of the welfare measurements showed that livestock-keepers indirectly valued one bull (with the given attributes) as worth €239, that is almost double what they have to pay on the market.

[78] The term inclusive value is also often named the log-sum (Greene, 2003b) or Hicks' CS (Train, 2003). The IVs provide the overall individual pay-off (see de Blaeij et al., 2005) of cattle seen as a bundle of different attributes

5.1.1.4. The first and remaining choices

As carefully explained in Chapter 2.4.1.1., a choice ranking approach was applied and one full ranking per respondent resulted in three choices. In order to compare the full ranking with an experimental setting where, firstly, respondents were only able to make one choice, the data set was split up and only the first choice was taken into account. Secondly, the last three choices were analysed in light of the implications for livestock-keepers' WTP measures.

5.1.1.4.1. Implications from the most preferred choice

The analysis of only the first choice per choice set implies that livestock-keepers selected their most preferred animal out of four alternatives and then switched to the next choice set without ranking the remaining three alternatives. The following table shows the value of the WTP measures for cows and bulls as well as the CS. The results are similar to those of the full ranking, at least possessing the same signs, but some attributes show higher values and the CS is considerably higher for cows as well as for bulls.

Table 12 displays the WTP values for **bulls** as derived from the first choice only. It is noteworthy that the same attributes are more insignificant in this model for bulls than in the full data set model, and were accordingly dismissed after a log likelihood ratio test had been conducted. One minor difference in significance was revealed only for the Ethiopian data set. The attribute "short and straight horns" which were significant in the full ranking mode did not show significance when only first choice was considered.

Table 12: WTP indicators for bulls' attributes according to the first choice

	Ethiopia		Kenya		all	
Attribute	**Coefficient**	**p-value**	**Coefficient**	**p-value**	**Coefficient**	**p-value**
Watering every day	-51	0.0000	-48	0.0010	-59	0.0000
Watering once in 3 days	39	0.0000	14	0.0386	34	0.0000
Tick tolerance	46	0.0000	15	0.0429	43	0.0000
Big body size	16	0.0059	Not significant		16	0.0007
Strong offspring	47	0.0000	25	0.0001	46	0.0000
Traction suitability	80	0.0000	33	0.0005	71	0.0000
Short and straight horns	Not significant		Not significant		-10	0.0584
Long and curved horns	-17	0.0099	Not significant		-20	0.0007
CS	299		281		322	

All values are significant at the 95% confidence level

The most remarkable result can be revealed from the Ethiopian model. Ethiopian livestock-keepers seem to place strong importance on some attributes when choosing the most favourable animal out of the choice sets. Among these are the attributes "watering once in 3 days" for which the WTP increased from €12 in the full ranking model to €39, "tick tolerance" for which the WTP went up from €27 to €46, "big body" with an increase in WTP from €8 to €16 and “strong offspring” with an almost triple rise in WTP from €17 to €47. The attribute “traction suitability”, which had already showed the highest WTP, also increased to the almost double amount, from €49 to €80 per bull. On the contrary, Kenyan livestock-keepers reveal similar selection behaviour, regardless of the fact if it was their first or one of the remaining three choices. The CS is almost the same in Kenya.

Regarding the data set for **cows** (Table 13), unlike for bulls, many attributes that were significant in the full rank model do not show significance anymore when only the first choice was extracted, and vice versa, some attributes became significant. As expected, the signs of the coefficients are the same in this model and the initial full rank model. For the **pooled model**, for full rank data set all attributes possess significant coefficients except the two attributes regarding the horns. In this model, “daily milk yield of more than 4 litres” and “long and curves horns” do not significantly drive livestock-keepers’ decisions for the first choice. On the other hand, many attributes show higher magnitudes implying that they are most important to livestock-keepers when opting for the best animal profile out of a choice set. These attributes are “watering once in 3 days” (WTP up from €9 to €17), “tick tolerance” (WTP up from €16 to €32), “big body” (WTP up from €8 to €13), and “annual calving frequency” (WTP up from €17 to €25). The CS for the pooled data set is also much higher for the first choice than for the full ranking model, with an increase from €134 up to €176.

Looking separately at the **country-specific** models, it is noteworthy, that in the Kenyan model the attribute “body size” switched to an insignificant behaviour. The attribute “0-2 litres milk per day” became more undesirable, with an increase in the negative WTP from -€20 to -€26. The other attributes display similar magnitudes of WTP indicators and also the CS differs only slightly (€189 to €170 for the full rank model). In Ethiopia, livestock-keeper’s decision for the first choice is, among other factors, also driven by the attribute “milk yield of more than 4 litres per day”. This attribute was considered insignificant in the full ranking model. However, the attribute “long and curved horns” does not prove to be significant any more when only the first choice for cows in Ethiopia is considered. Analogous to the bulls’ model for Ethiopia, livestock-keepers reveal much greater WTP for some cows’ attributes when they were constrained to make one choice only rather than being allowed to rank the animal profiles and thereby making four choices. These highly preferred attributes are “watering once in 3 days” (WTP up from €11 to €17), “tick tolerance” (WTP up from €16 to 33), “big body” (WTP doubling from €5 to €8) and “annual calving frequency” (WTP up from €16 to €36). The CS strongly increased as well, from €101 in the initial model to €133 for the first choice model.

Table 13: WTP indicators for cows' attributes according to the first choice

	Ethiopia		Kenya		all	
Attribute	**Coefficient**	**p-value**	**Coefficient**	**p-value**	**Coefficient**	**p-value**
Watering every day	-29	0.0000	-31	0.0000	-36	0.0000
Watering once in 3 days	17	0.0000	10	0.0106	17	0.0000
Tick tolerance	33	0.0000	13	0.0010	32	0.0000
Big body size	8	0.0001	Not significant		13	0.0000
One calf per year	26	0.0000	10	0.0081	25	0.0000
M1	Not significant		-26	0.0000	-20	0.0000
M3	6	0.0143	Not significant		Not significant	
Short and straight horns	Not significant		Not significant		-7	0.0015
Long and curved horns	Not significant		Not significant		Not significant	
CS	133		189		176	

All values are significant at the 95% confidence level

5.1.1.4.2. Implications from the rejected choices

Besides having a closer look only at the most preferred choice, one can also obtain useful information by examining those choices that were somehow rejected because they were only preferred in the second, third or fourth place within the full ranking process. The following discussion is on the last three remaining choices after having extracted the first choice from the data set.

When we begin with the **cow** model, one can see that for the pooled data set many attributes show the same WTP amounts as the full rank model (see Table 14). Only the attribute "tick tolerance" displays a severe decline from €16 to €6. Compared to that model, only when considering the last choices do livestock-keepers not let their selection be influenced by the attributes "watering one in 3 days" and "short and straight horns". The CS does not differ much between this model and the initial full rank model (€121 to €134).

In Kenya, in addition to "short and straight horns" and "long and curved horns", also "big body", and "annual calving frequency" produce insignificant coefficients leaving livestock-keepers' last choices to be influenced only by four attributes. "Tick tolerance" is one of the remaining attributes and livestock-keepers' WTP for it increased from €18 according to the full rank model to €20 in this case. "Watering once a day" is considered as worse with a slight decline in its WTP from -€40 down to -€47. Milk quantity seems to constitute a decision driver for the last choices compared to the first choice. The attribute "more than 4 litres milk yield per day" only became important after the most preferred cow had already been chosen. For the left over choices, livestock-keepers seem to consider a high milk yield as negative (WTP of -€13 per cow). One reason for that might be that livestock-keepers believe that cows giving "too much" milk per day require more feed supply and also become vulnerable to weakness.

This result can also be found in the cow data set for Ethiopia. A milk yield of "0-2 litres per day" whose incidence was not considered important in the full rank model now seem to have an impact on livestock-keepers' choices. Instead, the attributes "watering once in 3 days", "tick tolerance" and "big body" are not significant anymore. Together with the attributes "short and straight horns" and "> 4 litres milk yield" that were initially also insignificant, livestock-keepers' remaining choices after the first choice for cows in Ethiopia only depend on three attributes: "annual calving frequency", "0-2 litres milk per day" and "watering once a day". Nevertheless, the CS is the same as for the full ranking mode.

Table 14: WTP indicators for cows' attributes according to the last three choices

	Ethiopia		Kenya		all	
Attribute	**Coefficient**	**p-value**	**Coefficient**	**p-value**	**Coefficient**	**p-value**
Watering every day	-36	0.0000	-47	0.0000	-46	0.0000
Watering once in 3 days	Not significant		Not significant		Not significant	
Tick tolerance	Not significant		20	0.0000	6	0.0031
Big body size	Not significant		Not significant		4	0.0499
One calf per year	11	0.0000	Not significant		10	0.0000
0-2 litres milk/day	-6	0.0020	-14	0.0103	-9	0.0000
> 4 litres milk/day	Not significant		-13	0.0397	-8	0.0101
Short and straight horns	Not significant		Not significant		Not significant	
Long and curved horns	Not significant		Not significant		-6	0.0083
CS	87		175		121	

All values are significant at the 95% confidence level

The process of omitting the first choice and only looking at the rejected choices has severe implications for the significance of attributes in **bulls**. As presented in Table 15, not only does the attribute "watering once in 3 days", which was highly appreciated in the full ranked model, become insignificant, but so does as well "body size" and the two attributes on the size and shape of horns.

In the Kenyan model, besides the just mentioned attributes, the attribute "offspring" also does not play a significant role in ranking the last three choices within a choice set. In the Ethiopian model, on the other hand, livestock-keepers do take the attribute "watering once in 3 days" into consideration when selecting the next best bulls after the first choice. The WTP values of the significant attributes are in most cases, at least in the pooled and the Ethiopian model, lower than these of the initial model. The WTP for tick tolerance went down from €24 to €17 in the pooled model and down from €27 to €17 in the Ethiopian model, whereas the WTP for "strong offspring" decreased from €21 to €8 in pooled model but increased from €17 to €23 in the Ethiopian model. The WTP for traction suitable bulls dropped down for the pooled and the Ethiopian model but increased slightly for the Kenyan model (up from €39 to €41). The WTP magnitude for the attribute "watering once a day" stays stable in the

Ethiopian and pooled model but decreased by half in the Kenyan model (decrease from -€36 to -€67). The CS diminished for bulls in Kenya and in the pooled model but, most strikingly, increased for the Ethiopian model (increase by €25 from €223 to €248). One interpretation for this increase might be that the two "horn" attributes that were perceived as negative utility in the initial model are now not significant anymore and hence give rise to a slight increase in the overall WTP (the IV).

Table 15: WTP indicators for bulls' attributes according to the last three choices

	Ethiopia		Kenya		all	
Attribute	**Coefficient**	**p-value**	**Coefficient**	**p-value**	**Coefficient**	**p-value**
Watering every day	-62	0.0000	-67	0.0000	-65	0.0000
Watering once in 3 days	11	0.0114	Not significant		Not significant	
Tick tolerance	17	0.0001	15	0.0015	17	0.0000
Big body size	Not significant		Not significant		Not significant	
Strong offspring	23	0.0000	Not significant		8	0.0270
Traction suitability	39	0.0000	41	0.0005	39	0.0000
Short and straight horns	Not significant		Not significant		Not significant	
Long and curved horns	Not significant		-13	0.0080	Not significant	
CS	248		181		194	

All values are significant at the 95% confidence level

To summarise what can be learned from the remaining choices that were turned down as most preferred alternatives, is that livestock-keepers do not place as much care on the remaining choices as they do on picking the first alternative, i.e. many attributes are not significant anymore. That means the last choices are a kind of **arbitrary** between animals not possessing a certain desirable attribute that would have made the alternatives being the most preferred one. In Ethiopia, cows that are not tick tolerant and those with a small body are also left over for the last choices. For bulls, alternatives that were dismissed as first choice did not possess "watering once in 3 days" and "big body". The strong dislike for cattle that need water every day can be stressed when looking at the last choices because this is an attribute that, even for the remaining choices, was considered as intolerable with a negative WTP.

5.1.2. Results of the MXL model

Applying a MXL model aims to reveal taste variation for attributes on the basis of livestock-keepers' different socio-economic background and different production system parameters and to reveal the "source" of this heterogeneity.

As thoroughly elaborated in Chapter 2.4.2, the specification of the MXL model is the same for the basic MNL except for one or more random parameters in the indirect utility function (Revelt and Train, 1998) or some additional error components (Brownstone and Train, 1999). The focus here is on the random parameter specification, where randomness affects taste parameters. Each livestock-keeper gave rise to a panel of 21 choices (9 for bulls and 12 for cows) and therefore the **panel version** of MXL (Revelt and Train, 1998) was used. The 21 choices were derived by presenting three (for bulls) and four (for cows) full ranking choice sets as completely independent observations. The data thus is a panel with seven "time periods" corresponding to the seven choice sets faced by each respondent. These were estimated only for the pooled sample, including data from Kenya and Ethiopia. When a MXL model is applied, the aim is to identify the additional information that can be gleaned when the transition is made from the basic MNL to the MXL approach. The MXL estimates presented here are obtained via simulated maximum likelihood (ML) using 1000 and 125 **Halton** draws[79].

Three different MXL models were applied; each tested for heterogeneity in livestock-keepers preferences, but with **different foci**. First of all, a MXL model will be estimated that permits all previously found significant attributes apart from "price" to vary randomly among livestock-keepers (see Table 16). Then, two blocks of parameters were formed; each consisting of characteristics that determine livestock-keepers heterogeneity and that are likely to influence livestock-keepers choice for cattle. For both "blocks" a single MXL model will then be estimated. The two blocks are characterised as follows:

- Socio-economic parameters: country, social status in village, size of household, income per year, education
- Livestock production parameters: production system, size of cattle herd, market linkage, availability of arable land

The meaning of the parameters for livestock-keepers in the research area is further described in the two sections 5.2.2.1 and 5.2.2.2.

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[79] Halton draws (=non-random intelligent drawing mechanisms) are designed to cover the integration space in a more uniform way, and therefore can significantly reduce the number of draws required (Ben-Akiva et al., 2001). Train (1999, 2003) thoroughly examined Halton draws in the context of maximum simulated likelihood on discrete choice models revealing that Halton draws provide higher accuracy than a comparable number of independent draws. Halton draws further reduce simulation error (Bhat, 2000; Train, 1999). Bhat (2000) tested Halton sequences for mixed logit estimation and found their use to be vastly superior to random draws. Concerning the **number of Halton draws**, Train (1999) recommends 100 to 1000 draws. Revelt and Train (1999) make the point that the number of Halton draws that are used in simulation does not seem to materially affect the results if more than 100 draws are used. Their study further revealed that there is essentially no difference between 1000 and 10,000 draws. With 100 draws, the standard deviations are slightly lower than with 1000 or 10,000 draws, and the absolute deviations are slightly higher, with these differences increasing with the number of choice situations. This result suggests that the number of draws should rise with the number of choice situations that are used in conditioning (Revelt and Train, 1999). Bhat (2000) found that the simulation error in the estimated parameters was lower using 100 Halton numbers than 1000 random numbers and to be more precise, he, in fact, showed that with **125 Halton draws** the simulation error to be half as large as with 1000 random draws and smaller than with 2000 random draws.

5.1.2.1. General heterogeneity in preferences for cattle attributes among individuals

Table 16 presents the estimates of the MXL models for cows and bulls, with all remaining and indicated coefficients being significant at the 95 percent confidence level. The overall **fit of the models** to the data is good, as can be seen from the high pseudo-R^2 values, exceeding 0.4. Using the **log-likelihood test,** it was discovered that the MXL model outperforms the basic MNL model for the pooled data set.[80] 1000 Halton draws were used.

The **price** coefficient was always treated as a fixed variable across the population in such a way that the distribution of WTP for each non-price attribute (which is the ratio of the attribute's coefficient to the price coefficient) has the same distribution as the attribute's coefficient (Train, 1998). The price is set as fixed in order to avoid positive signs. All of the non-price coefficients are specified as being **normally** distributed in the population. The mean and the standard deviation of each coefficient are hence sought to be estimated.

Applying MXL on the **cow** data set clearly shows significant standard deviations for all attributes that were initially included. The two attributes "short and straight horns" and "long and curved horns" were dismissed before running the MXL model because in the basic MNL they showed insignificant p-values (see Table 8).

One can infer from the MXL model that there is indeed taste variation among different groups of livestock-keepers. In the case of preference for the attribute "calving frequency", for example, one can infer that 82 percent ($(Pr(ß>0)=\Phi(0,0.46,0.50))$) of livestock-keepers liked to keep cows with an annual calving rate and that only 18 percent of individuals disliked this attribute. This relatively strong preference for obtaining calves in a biannual cycle can be explained by the frequent occurrence of droughts. In drought and generally in dry seasons it is not preferable for cows to conceive. Many livestock-keepers prefer healthy calves with a good chance to survive rather than many calves and a high mortality and this model seeks to understand which livestock-keepers expose this preference.

[80] The test statistic is given by -2(-3335.8+3090.7)=490.2 for cows and -2(-2467.4+2367.8)=199.2 for bulls and the degrees of freedom are 7 for cows and 9 for bulls. The null hypothesis that the significance of the contribution of the random effects is equal to zero can be easily rejected, i.e. the basic MNL is rejected relative to the MXL.

Table 16: Results of the MXL model with all significant attributes randomly distributed

Cows			Bulls		
Attribute	**Coefficient**	**p-value**	**Attribute**	**Coefficient**	**p-value**
Random parameters in utility functions					
Calving once a year	0.459	0.0000	Strong offspring	0.314	0.0000
Watering once in 3 days	0.299	0.0000	Watering once in 3 days	0.220	0.0002
Watering once a day	-1.202	0.0000	Watering once a day	-0.906	0.0000
Tick tolerance	0.487	0.0000	Tick tolerance	0.350	0.0000
Big body size	0.196	0.0000	Big body size	0.106	0.0040
> 4 litres milk/day	-0.155	0.0003	Long and curved horns	-0.192	0.0000
0-2 litres milk/day	-0.353	0.0000	Short and straight horns	-0.098	0.0362
			Traction suitability	0.673	0.0000
Nonrandom parameters in utility functions					
Price	-0.030	0.0000	Price	-0.015	0.0000
Standard deviations of parameter distributions					
Calving once a year	0.499	0.0000	Strong offspring	0.372	0.0000
Watering once in 3 days	0.604	0.0000	Watering once in 3 days	0.688	0.0000
Watering once a day	1.035	0.0000	Watering once a day	0.648	0.0000
Tick tolerance	0.257	0.0006	Tick tolerance	0.280	0.0011
Big body size	0.296	0.0000	Big body size	0.447	**0.6979**
> 4 litres milk/day	0.213	0.0381	Long and curved horns	0.110	**0.4273**
0-2 litres milk/day	0.453	0.0000	Short and straight horns	0.037	**0.7476**
			Traction suitability	0.515	0.0000
Log likelihood	-3090.7		Log likelihood	-2367.8	
ρ^2	0.5		ρ^2	0.48	
Number of observations	4416		Number of observations	3276	
Groups in panel	368		Groups in panel	364	
Fixed number of observations per group	12		Fixed number of observations per group	9	
Halton draws	1000		Halton draws	1000	

Relatively high variation in livestock-keeper's taste seem to occur for the attribute "wat_3" with only 69 percent preferring this attribute, and 31 percent disliking it ((Pr(ß>0)=Φ(0,0.30,0.60)). The results for the attribute "wat_1" show, according to expectations, relatively little taste intensity. 87 percent of individuals would rather not purchase cows that need watering once a day, while 13 percent had no objections to this attribute in cows ((Pr(ß>0)=Φ(0,-1.20,0.1.04)). That could be due to the fact that cows were often kept within the boundaries of the villages where there was permanent water supply. This is true in particular for sucking cows to better monitor them and to take care of the calves and for milking cows contributing to the daily nutrition supply.

Taste variation is quite intense with respect to the attribute "body size". 75 percent like large-framed cows while 25 percent apparently prefer small-framed animals ((Pr(ß>0)=Φ(0,0.20,0.30)).

Regarding the attribute "being tick tolerant" it is safe to say that there is very little variation of taste intensity, as 97 percent of livestock-keepers are in favour of tick tolerant cows and only 3% dislike this attribute ((Pr(ß>0)=Φ(0,0.49,0.26)).

Livestock-keepers are quite taste homogeneous when a decision is made about the preferred daily milk yield. 22 percent of livestock-keepers prefer a daily milk yield of “0-2 litres” ((Pr(ß>0)=Φ(0,-0.35,0.45)). The same magnitude in taste variation was found for the attribute “> 4 litres milk”, with again 78 percent of individuals disliking and 22 percent preferring the attribute ((Pr(ß>0)=Φ(0,-0.16,0.21)). This result strengthens the strong preference for an average daily milk yield of “0-2 litres” (the status quo level) and also shows that high productivity in term of milk yield is not favourable for livestock-keepers on the Borana plateau. The higher the milk yield the more vulnerable are cows to drought stresses.

The MXL model for **bulls** shows that all attributes but the horn shape and size (“horn_1” and “horn_3”) and the body size (“big”) seem to be randomly distributed across individuals. These three attributes take on insignificant standard deviations and hence the variation in choice does not depend on these attributes but has other driving factors.

Relatively little taste variation is given for the attribute “traction”, as 90 percent of livestock-keepers would prefer bulls that are suitable for traction while 10 percent did not mind keeping bulls that cannot be used for traction ((Pr(ß>0)= Φ(0,0.67,0.52)). This distribution met the expectations because individuals whose livelihood used to depend entirely on livestock nowadays expand their activities to crop production on a self-sufficiency level. Due to the lack of machines, cattle draught is the only source of power that can be used for ploughing large arable areas that are often characterised by poor accessibility and hard soil texture.

The apparent dislike for bulls that are not tick tolerant was again according to expectations. 90 percent prefer bulls being tolerant to ticks, but the remaining 10 percent would also purchase bulls with a low level of tick tolerance ((Pr(ß>0)= Φ(0,0.35,0.28)).

The attribute “offspring” displays a similar distribution, with 80 percent of the livestock-keepers preferring bulls with strong offspring and 20 percent not considering strong offspring as a favourable attribute that determines their choices when purchasing bulls ((Pr(ß>0)=Φ(0,0.31,0.37)).

The result for the attribute “wat_3” is quite stunning in regarding the obvious taste variation which was detected for it as with the cow model. It was expected that there would be little variation in taste intensity for this attribute with the majority of livestock-keepers being in strong favour of bulls that can withstand water shortage up to three days because bulls are usually kept far away from villages (depending on the availability of pasture), and thereby being tracked over a period of many months. During this time and particularly in dry seasons bulls are tracked to water points only once in three days. In any case, only 63 percent of livestock-keeps are in favour of bulls that are able to live without water intake for up to three days while the remaining 37 percent derive higher utility from bulls that need water either once in two days or every day ((Pr(ß>0)=Φ(0,0.22,0.69)). Again, this can be explained by the change in land use and production systems in which livestock-keepers nowadays live, the resulting increase in crop production and the resulting sedentarisation in areas with permanent water supply. This development enables individuals to keep their herds near the villages and thereby also have easy access to the bulls when needed for traction, for instance. The attribute "watering once a day" on the other hand shows a neglectable variation in taste among livestock-keepers with 92 percent disliking this attribute ((Pr(ß>0)=Φ(0,-0.91,0.65)). Hence individuals showing low preference for the attribute "watering once in 3 days" do not necessarily prefer "watering once a day" but would opt for bulls being able to withstand water shortage for two days.

5.1.2.2. The source of livestock-keepers taste heterogeneity

Having estimated the general MXL model, it came to light that there indeed existed great variance among individuals for preferences of some of these attributes. This variance eventually might influence livestock-keepers' choices for cattle. A further task within this research work is now to best fit the MXL model, taking into account a range of livestock-keepers' parameters that might explain this heterogeneity.

For instance, the result for the attribute "body size" in cows uncovers that the majority of livestock-keepers (75 percent) associated positive utility with large-framed cows, but the question arises "what kind" of livestock-keepers are responsible for the remaining 25 percent disliking this attribute. It is important to know which **group of individuals** prefers small-framed cows because the pure Borana is rather big-sized and the preference for small cattle can have a contradicting impact on conservation efforts. Likewise the dislike for other attributes for cows and bulls can positively or negatively influence the success of conserving the Borana breed and therefore, section 5.2.2.2.1 and 5.2.2.2.2 attempt to reveal the source of heterogeneity in livestock-keepers that are responsible for taste variation. A first model takes into account socio-economic parameters while the second model tests whether parameters related to the production process have influence on the variation in preferences for some attributes.

In order to determine "who" likes the expression of an attribute and "who" does not, the MXL model formula previously used for detecting "general" heterogeneity was modified slightly so that the source of the underling heterogeneity could be identified. In the MXL model setting the indirect utility function (see Equation (7) in Chapter 2.4.1) can be rewritten as follows (Glasgow, 2000; Train, 2003):

$$U_{nj} = V_{nj}(X_{nj}) + (Z_{ij}\eta_i + \varepsilon_{nj}) \qquad (19)$$

The stochastic error term is modified by including Z_{ij} as a vector of characteristics that can vary over individuals i, alternatives j or both, and η_i is a random term with a mean 0 that varies over individuals i according to a specific distribution (here a normal distribution). In a **random-coefficient model**, as applied here, Z_{ij} are contained in X_{nj} (Glasgow, 2000). The Z_{ij} parameters are allowed to vary randomly from individual to individual assuming a normal density (see Chapter 2.4.2.). The **Halton draws were reduced** from 1000 that were applied in the initial MXL model, to **125 draws**. That was due to the complexity of the model and also because 125 draws are still regarded sufficient.

These attributes that do not seem to vary randomly across the population (i.e. that showed standard deviations greater than 0.2[81]) were treated as fixed variables. This was the case for three attributes in the bull model ("short and straight horns", "long and curved horns" and "big body"; see Table 16) while in the cow model all included attributes seem to be randomly distributed among individuals.

Furthermore, these cattle attributes that showed significant standard deviations but in which the taste variation were nevertheless very poor were also treated as fixed variables. As a rule it was constituted that a taste **variation of less than 10 percent** was not considered heterogonous enough to be eligible for detecting the possible source of this variation and were set as fixed among all individuals. The coefficient of "tick tolerance" in the cow model conforms the prior expectations with 97 percent of livestock-keepers prefer cows expressing high levels of tick tolerance, and hence no taste variation can be detected and there is no need to let this parameter be distributed randomly among different groups of livestock-keepers. Detecting the source of heterogeneity would only apply for 3 percent of livestock-keepers whose tastes differ and this is not worth investigating. For the attribute "watering once a day" for bulls (92 percent with positive attitude versus only 8 percent of livestock-keepers with negative attitude towards it) there is also no need to expose the source of heterogeneity because this little taste variation can be neglected.

[81] The rule of thumb according to Underwood (1997) says that if the p-value is greater than 0.2., it is very likely that the coefficient of the attribute is insignificant. A small p-value means that it is very unlikely that the coefficients are randomly (very unlikely that they are not significant) (see also Agresti, 1996).

Finally, the following attributes are treated as random because it seems promising that they could be significantly related to some socio-economic parameters of livestock-keepers as well as to production systems parameters (parameters were mentioned above):

- Cow model: "big body", "annual calving frequency", "0-2 litres daily milk yield", ">4 litres milk yield", "watering once in three days", "watering once a day"
- Bull model: "strong offspring", "watering once in three days", "tick tolerance", "traction suitability"

The other, not listed, attributes were all set as fixed because they either do not have any impact at all on the choice for cattle or show no significant standard deviation on the general MXL model or do not seem to vary across livestock-keepers in the first place. Note that the attribute price was again fixed in order to avoid positive behaviour.

5.1.2.2.1. Socio-economic specific taste variation across livestock-keepers

As already mentioned, the following socio-economic parameters were tested for having impact on some randomly distributed cattle attributes: "country", "household size", "income", "cultural status", and "education". The parameter "**country"** takes on two values, 1 for Kenya and 0 for Ethiopia. The "**household size**" of respondents was included because it is one of the indicators for wealth and the prospects of a household. The number of household members has an impact on the living standard, on the share of members receiving educational training and how individuals value the traditional way of life. Regarding pastoralists' life, it was long recognised that with a shift from pure livestock production in nomadic systems to sedentary production strains, the household size decreases (see e.g. Thornton et al., 2003). Only members who currently live in the respondent's household were counted for this continuous parameter. Despite a general increase in population growth rate for the Borana zone, household sizes tend to decrease due to youth drain. Young Borana people are increasingly attracted to opportunities outside the traditional cattle herding sector and they seek to move to urban areas (Coppock, 1994, p. 75). The desire for and planning of children is also affected by the number of cattle and should be proportional to a household's economic condition, and reflects the herd size (Coppock, 1994, p. 75). For simplicity, the "**level of education"** was reduced from a category variable to a simple binary variable, either the head of household (in most cases the respondent) attended school once in a lifetime (=being literate) or never attended school (=being illiterate). The level of illiteracy is again strongly linked to the degree of sedentarisation of livestock-keepers. Many livestock-keepers who pursue pure pastoral lives in which animals as well as families are not sedentary do not have the opportunity to send children to school simply because of a lack of access. The "**social status"** is captured by a dummy variable of either being a village chief/elderly (=*aba ola*) or not. This parameter is again related to the wealth of the household because usually individuals can only become chiefs and form their own village (*ola*) when they possess a certain amount of cattle (and money) and also only when they are accepted within the Borana community.

Further improvement of this MXL model was carried out by omitting those parameters describing livestock-keepers which did not seem to significantly explain livestock-keepers' preference for at least one cattle attribute, i.e. which did not show a significant p-value for at least one attribute. Regarding the socio-economic parameters for cows, three parameters did not expose any significant impact on the choice for cows: namely level of education of respondents, his/her cultural status in the village and the level of his/hers household income. The level of income does, however, seem to have an impact on the choice for bulls, unlike the two parameters "education" and "culture status". These two parameters can be omitted for bulls and cows alike, signifying that livestock-keepers purchase behaviour and taste preference for cattle is not driven by their wealth (income and cultural status). Table 17 displays the results for the best fitting MXL models including socio-economic parameters.

For the **cow** model that leaves only two parameters with possible impact on choice and, hence, as being the source for taste variation, namely the **country** and the **size of household**. The fact that the research was conducted in two different countries (Kenya and Ethiopia, coded as Kenya = 1; Ethiopia =0) had a large impact on the model's outcome. The taste variation in one attribute of cows (calving frequency) could be traced back to the different region in which respondents keep their cattle. From those livestock-keepers preferring an annual calving frequency, 82 percent lived in Ethiopia (($Pr(\beta>0)=\Phi(0,-0.46,0.50)$)). Putting it the other way round, 82 percent of the Kenyan livestock-keepers did not prefer an annual calving frequency but derive higher utility from a cow conceiving a calf once every two years.

The second socio-economic parameter with significant impact on the taste preference for cow attributes is the "size of household". The larger the household size, the higher is the probability that livestock-keepers derive positive utility from the attributes "watering once a day"[82], "watering once in 3 days"[83], ">4 litres milk"[84], "0-2 litres milk"[85] and "annual calving

[82] $Pr(\beta>0)=\Phi(0,0.066,0.993)$

[83] $Pr(\beta>0)=\Phi(0,0.066,0.626)$

[84] $Pr(\beta>0)=\Phi(0,0.023,0.241)$

[85] $Pr(\beta>0)=\Phi(0,0.023,0.450)$

frequency”[86]. A larger household size means more labour available for herding, milking etc. and this is reflected in the preference for an annual calving rate. More frequent calving leads to larger herds (under normal conditions) and these are only manageable with sufficient labour forces.

Table 17: Taste variation across livestock-keepers with different socio-economic background

Cows			Bulls		
Attribute	**Coefficient**	**p-value**	**Attribute**	**Coefficient**	**p-value**
Random parameters in utility functions					
Calving once a year	0.344	0.0000	Strong offspring	0.152	0.0023
Watering once in 3 days	0.149	0.0460	Watering once in 3 days	0.149	0.0424
Watering once a day	-1.223	0.0000	Tick tolerance	0.213	0.0000
0-2 litres milk/day	-0.351	0.0003	Traction suitability	0.551	0.0000
> 4 litres milk/day	-0.147	0.0051			
Big body size	0.157	0.0001			
Nonrandom parameters in utility functions					
Price	-0.028	0.0000	Price	-0.013	0.0000
Tick tolerance	0.477	0.0000	Short and straight horns	-0.116	0.0161
			Long and curved horns	-0.188	0.0000
			Big body size	0.087	0.0192
			Watering once a day	-0.794	0.0000
Heterogeneity in mean with socio-economic parameters					
Country*calving	-0.457	**0.0000**	***Country****offspring	-0.068	0.5856
Country*wat3	-0.231	0.0596	Country*wat3	0.029	0.8409
Country*wat1	-0.231	0.0596	Country*tick	-0.180	0.1550
Country*m1	-0.191	0.1083	Country*traction	-0.357	**0.0094**
Country*m3	-0.191	0.1083	***Size_HH****offspring	0.057	**0.0002**
Coruntry*big	-0.166	0.0805	Size_HH*wat3	0.021	0.1575
Size_HH*calving	0.059	**0.0000**	Size_HH*tick	0.048	**0.0005**
Size_HH*wat3	0.066	**0.0000**	Size_HH*traction	0.081	**0.0000**
Size_HH*wat1	0.066	**0.0000**	***Income****offspring	0.0003	0.6136
Size_HH*m1	0.023	**0.0379**	Income*wat3	0.0012	**0.0491**
Size_HH*m3	0.023	**0.0379**	Income*tick	0.0006	0.2051
Size_HH*big	-0.001	0.9085	Income*traction	-0.0005	0.3507
Standard deviations of parameter distributions					
Calving once a year	0.498	0.0000	Strong offspring	0.363	0.0000
Watering once in 3 days	0.626	0.0000	Watering once in 3 days	0.707	0.0000
Watering once a day	0.993	0.0000	Tick tolerance	0.269	0.0001
0-2 litres milk/day	0.450	0.0000	Traction suitability	0.488	0.0000
Big body size	0.232	0.0010			
> 4 litres milk/day	0.241	0.0082			
Log likelihood	-3059.9		Log likelihood	-2351.3	
ρ^2	0.50		ρ^2	0.48	
Number of observations	4416		Number of observations	3276	
Halton draws	125		Halton draws	125	

Three parameters seem to explain the source of heterogeneity for taste preference for **bulls**, namely, similar to the cow model, “**country**” and “**household size**”, and additionally the level of **income.** The socio-economic parameter “household size” seem to be most influential, explaining the source of taste variation in three attributes: “offspring”, “tick tolerance” and “traction suitability”. For all three attributes it could be seen that the larger the household size

[86] Pr(ß>0)=Φ(0,0.059,0.498)

the more likely it was that livestock-keepers prefer these attributes. Households with higher numbers are more likely to select bulls that were tick tolerant, that are suitable for traction and that provide strong offspring.

Only the preference for the attribute “traction suitability” in the bull model seems to differ among livestock-keepers in both countries. 78 percent of livestock-keepers who select bulls that are suitable for traction reside in Ethiopia (($Pr(ß>0)=\Phi(0,-0.38,0.49)$)), or in other words, 78 percent of Kenyan livestock-keepers do not expect higher utility from traction suitable bulls. This result underlines the importance of additional income generation through crop production in Ethiopia and, with it, the need for keeping bulls for ploughing. The parameter “income” only has an impact on the preference for the attribute “watering once in three days”, revealing that the higher the income, the higher the share of livestock-keepers deriving higher utility from bulls that can withstand water shortage for up to three days than from bulls needing water once a day or once in two days (($Pr(ß>0)=\Phi(0, 0.001,0.71)$)). This result confirms the relation between income, herd size and land use. Livestock-keepers with very low income might not be able to keep many cattle and might not be able to send their herds to *foora* (satellite, temporary camps far away). Low income households increasingly tend to add income by crop production and hence do not need adaptive bulls in the first place. It is also common, particularly for households with low income (and few cattle), to borrow bulls when necessary.

The source of heterogeneity cannot be detected by this model and by the socio-economic parameters that were included here for all other randomly distributed attributes, although these showed significant standard errors. Hence, there must be other factors that have an effect on the taste variation but that cannot be captured in this choice model. These factors could be either related to other socio-economic household characteristics besides the ones tested here or to other cattle attributes driving the purchase decisions of livestock-keepers but that are not part of the attributes of the animal profiles in the choice sets (e.g. coat colour, head and ear shape, udder condition, eye condition). The attribute “body size” in cows, for example, reveals a significant standard deviation but none of the chosen socio-economic parameters are significantly related to it, i.e. livestock-keepers are heterogeneous about it but why it is so cannot be explained at this point. The subsequent model in which production system parameters are included might elucidate this question.

5.1.2.2.2. Taste variation among livestock-keepers in different production systems

Four parameters explaining the mode of cattle husbandry in the research area were included in the MXL model: market linkage, availability of arable land, size of cattle herd (only adult animals were counted), and the production system *per se* (pastoralism[87] or agro-pastoralism[88]). 32 percent of respondents stated to life in a pure pastoral system and 68 percent in agro-pastoralism (see Table 6 in Chapter 4). Both systems are appropriate for the arid/semi-arid conditions in northern Kenya and southern Ethiopia. Pastoralism is a grass-based system, meaning that more than 90 percent of dry matter fed to animals comes from rangelands, pastures, annual forages and purchased feeds and less than 10 percent from crops. The system's annual average stocking production rates are less than 10 livestock units (LU) per ha agricultural land. Agro-pastoral systems are mixed farming systems with more than 10 percent of the dry matter fed to animals coming from crop by-products and stubble or more than 10 percent of the total value of production comes from non-livestock farming activities (i.e. another source of income besides livestock). The **production system** is said to be a crucial factor leading to changing herd compositions and genetic dilution of cattle (Rege and Gibson, 2003, p. 324). Crossbreeding activities are assumed to increase with higher degree of sedentarisation. McPeak and Little (2005) further suggest that sedentarisation leads to higher vulnerability in livestock losses in droughts and hence in food security. The reasons for accelerating sedentarisation and the accompanying change to agro-pastoral systems are manifold: population pressure, shrinking rangelands, and privatisation of resources but also the desire for diversification into town-based activities and benefits of sedentarism as promoted by governments (improved access to formal education, health care, markets etc.).

The wealth of livestock-keepers is often expressed by the **herd size** rather than by any other form of income or status symbol (Coppock, 1994). This parameter will be considered in the model because it is linked diversely to various other factors related to cattle production in the research area. Small herds may not be able to cope as well as large herds when faced with drought times (Tacher, 1983). Keeping larger herds results in a bigger share of milk for home

[87] Pastoralists' livelihoods almost entirely depend on livestock production and more precisely on tending herds of domesticated animals. Only a few products come from non-livestock farming activities. Some crops might be cultivated on a self-sufficiency level, albeit this is infeasible in many marginal areas. Focusing on the income, a commonly used definition in the literature is that in pastoralist households at least 50 percent of household gross revenue must be derived from livestock or livestock-related activities (Swift, 1998).

[88] As per definition, agro-pastoralists economically depend to more than 50 percent on farming activities (in terms of gross revenue) and to 10 to 50 percent on livestock production (Swift, 1998). They may be pastoralists that choose to settle and to pursue a coexistence of both agricultural and grazing activities.

consumption and higher income from livestock. Further, livestock-keepers with larger herds tend to be located in drier areas (McPeak and Little, 2005, p. 102). It would be interesting to know if these facts lead to taste variation for cattle attributes.

The availability of "**arable land**" was included as a dummy variable although it seems to be strongly linked to the production system. Clearly, sedentarisation and changing land use with a shift to agriculture as additional source of income are only feasible when settling in areas where the land is fertile and appropriate enough to be cultivated. Nevertheless, both parameters could be considered independently from each other because family and animal herds are often treated separately from each other. Livestock-keepers can keep their cattle in pure pastoral systems but, at the same time, maintain a livelihood in which they had already started to produce some crops because, unlike the cattle herds, they became sedentary.

The parameter "**market access**" is included as a dummy variable. It is widely assumed that market extension as a source of biodiversity loss (Tisdell, 2003, p. 370) is also applicable to the genetic dilution of cattle. The same author also suggests that increased market activity reduces the number of surviving breeds and competition also accelerates the process of replacing local breeds.

Table 18 presents how these parameters and which of them, in the first place, have significant impact on the preference for cattle attributes. First of all, it is noteworthy that for the bull model the parameters "herd size" and "market linkage" did not show significance for at least one attribute and were hence omitted in the final model. In the case of the cow model, the parameter "herd size" indeed showed significance relation to some of the cattle attributes, as well as the other parameters "market linkage", "availability of arable land" and "being a pastoralist". The estimated standard deviations of the finally included parameters are highly significant, indicating that parameters did indeed vary in the population.

The fact that livestock-keepers seem to have homogenous preferences for bull attributes no matter how many cattle they herd is interesting because the choice for cows, in contrast, is influenced by the herd size. An explanation for it is that cows are more important to a herd with a ratio usually ranging between one or two bulls per 10 cows. Livestock-keepers might possess huge herds with more than 200 cows but nevertheless place relatively little importance on bulls and so only keep one or two bulls for mating. When deciding the purchase of a bull, livestock-keepers did not shape their choice according to how many bulls or cows they might keep.

Table 18: Taste variation across individuals in different production systems

Cows			Bulls		
Attribute	**Coefficient**	**p-value**	**Attribute**	**Coefficient**	**p-value**
Random parameters in utility functions					
Calving once a year	0.374	0.0000	Strong offspring	0.216	0.0000
Watering once in 3 days	0.213	0.0044	Watering once in 3 days	0.143	0.0425
Watering once a day	-1.224	0.0000	Tick tolerance	0.307	0.0000
0-2 litres milk/day	-0.320	0.0000	Traction suitability	0.614	0.0000
> 4 litres milk/day	-0.127	0.0152			
Big body size	0.192	0.0001			
Nonrandom parameters in utility functions					
Price	-0.028	0.0000	Price	-0.014	0.0000
Tick tolerance	0.480	0.0000	Short and straight horns	-0.110	0.0203
			Long and curved horns	-0.181	0.0001
			Big body size	0.100	0.0064
			Watering once a day	-0.812	0.0000
Heterogeneity in mean with socio-economic parameters					
Pastoralism*calving	0.010	0.9189	***Pastoralism****offspring	0.379	**0.0002**
Pastoralism*wat3	0.220	0.0513	Pastoralism*wat3	0.583	**0.0000**
Pastoralism*wat1	0.220	0.0513	Pastoralism*tick	0.279	**0.0089**
Pastoralism*m1	0.065	0.5976	Pastoralism*traction	-0.060	0.5683
Pastoralism*m3	0.065	0.5976	***Arable_land****offspring	0.373	**0.0272**
Pastoralism*big	-0.455	**0.0000**	Arable_land*wat3	0.050	0.7814
Herd_size*calving	0.003	0.2442	Arable_land*tick	0.071	0.6287
Herd_size*wat3	0.001	0.7453	Arable_land*traction	0.893	**0.0000**
Herd_size*wat1	0.001	0.7453			
Herd_size*m1	-0.002	0.3882			
Herd_size*m3	0.002	0.3882			
Herd_size*big	0.009	**0.0010**			
Market_access*calving	0.359	**0.0001**			
Market_access*wat3	0.248	0.0736			
Market_access*wat1	0.248	0.0736			
Market_access*m1	0.091	0.4082			
Market_access*m3	0.091	0.4082			
Market_access*big	-0.046	0.6845			
Arable_land*calving	-0.548	**0.0001**			
Arable_land*wat3	-0.178	0.3445			
Arable_land*wat1	-0.178	0.3445			
Arable_land*m1	-0.221	0.1716			
Arable_land*m3	-0.221	0.1716			
Arable_land*big	0.070	0.6223			
Standard deviations of parameter distributions					
Calving once a year	0.494	0.0000	Strong offspring	0.381	0.0000
Watering once in 3 days	0.602	0.0000	Watering once in 3 days	0.705	0.0000
Watering once a day	1.002	0.0000	Tick tolerance	0.304	0.0000
0-2 litres milk/day	0.429	0.0000	Traction suitability	0.455	0.0000
> 4 litres milk/day	0.274	0.0015			
Big body size	0.243	0.0008			
Log likelihood	-3067,1		Log likelihood	-2351.9	
ρ^2	0.5		ρ^2	0.48	
Number of observations	4416		Number of observations	3276	
Halton draws	125			125	

The preference for certain attributes for **cows**, on the other hand, is indeed determined by the size of the cattle herd. The larger the size of the herd, the less likely livestock-keepers are to opt for large cows ($Pr(ß>0)=\Phi(0,0.009,0.24)$). Continuing with the model for cows, the parameter "being a pastoralist" only determines the preference for one attribute: the "body size". Livestock-keepers who live in pure pastoral systems are less likely to derive positive utility from large-framed cows. In fact, only three percent of individuals aiming for large cows practise a pure pastoral way of life and 97 percent of livestock-keepers preferring large cows are agro-pastoralists ($Pr(ß>0)=\Phi(0,-0.46,0.24)$). This finding is not according to expectations because it was assumed that individuals pursuing the traditional Borana land use would prefer the pure large-framed Borana cows. One explanation might be the better endurance of smaller cows in droughts. The fact that they perceive the large-framed cows as less attractive could have negative consequence on the conservation of the EB, that is, in comparison to other breeds and Borana subtypes large-framed.

A variation in the parameter "market availability" also resulted in taste variation of one attribute, namely "calving frequency" ($Pr(ß>0)=\Phi(0,0.36,0.49)$). 77 percent of livestock-keepers who have proper access to a nearby market place display a high preference for cows that conceive once a year; the other 23 percent of individuals who prefer an annual calving frequency do not have proper market access. This result emphasises that productivity in terms of high fertility and a tight calving circle of one year were of greater importance in areas of higher market transactions, enabling livestock-keepers to sell their calves and milk products. These areas can also supply better veterinarian services etc. facilitating successful breeding and calf management.

Lastly, the parameter "arable land" determines the taste variation for one cow attribute, namely "calving frequency"[89]. Only 14 percent of respondents who have proper access to land where crop cultivation would be potentially feasible derive positive utility from an annual calving frequency. 86 percent of livestock-keepers wishing to purchase cows that conceive one calf every year do not have the option of generating additional income through crop production because they live in areas where no arable land exists. Putting it the other way round, 86 percent of the livestock-keepers with the option to cultivate arable land would prefer a biannual calving frequency over an annual frequency.

Having a closer look at the **bull** model, it is clear that the parameter "**being a pastoralist**" (coded 1= pastoralist; 0= agro-pastoralist) has a significant impact on the livestock-keepers' preferences for the attributes "offspring"[90], "watering once in three days[91]" and "tick tolerance"[92]. The majority of individuals preferring strong offspring (84 percent) live in pure

[89] $Pr(ß>0)=\Phi(0,-0.55,0.49)$

[90] $Pr(ß>0)=\Phi(0, 0.38,0.38)$

[91] $Pr(ß>0)=\Phi(0, 0.58,0.71)$

[92] $Pr(ß>0)=\Phi(0,0.28,0.30)$

pastoral systems. The other 16 percent of livestock-keepers, who place importance on strong offspring, embed their livestock keeping into agro-pastoral systems.

The taste variation for the attribute “watering once in three days” is characteristic for 79 percent of the pastoralists who prefer this water frequency and hence 21 percent of agro-pastoralists place positive utility on it. This result is according to expectations because, in particular, pastoralists chose their cattle due to this vital adaptive attribute. The share of 21 percent not preferring “wat_3” can be explained by the minor importance of bulls for pastoralists. That is because pastoralists only use their bulls for mating and not for traction use. Pastoralists sent herds that consist of cows and a few bulls (the ratio lies around one or two bulls per ten cows) to distant temporary pastures (*foora*) for the best part of the year (or at least in dry seasons) and hence bulls and cows were required to adapt well to water shortage. The 21 percent of pastoralists, who do not derive any positive utility from bulls that are able to adapt to three days water shortage, might not include bulls into the herds that are sent far away and thus other attributes might be more important for them. Many pastoralists (particularly with low numbers of cattle) do not even own their own bulls but borrow them from other livestock-keepers for mating from time to time or simply mix up their herds with other livestock-keepers’ herds that include bulls. Agro-pastoralists, on the contrary, keep bulls for both purposes (although many bulls used for ploughing are castrated) but they do not seem to be very concerned about their bulls being well-adapted to water shortages.

82 percent of livestock-keepers deriving positive utility from tick tolerant bulls are pure pastoralists, whereas among agro-pastoralists only 18 percent prefer bulls with this tolerance. This result was expected as well. Due to the long walks through heavily tick loaded bushes that bulls in pastoral systems have to endure, it was expected that the majority of pastoralists prefer tick tolerant bulls. On the other hand, bulls that serve agro-pastoralists as a source of draught power do not need to be very tolerant to ticks because plain arable land is not very infested by ticks. Overall, it seems that agro-pastoralists are not very likely to prefer adaptive traits such as the need for water and tick tolerance.

The high number of attributes obviously varying due to consumer heterogeneity in the production system gives rise to separate models for “pastoralists” as well as for “agro-pastoralists” in order to reveal absolute welfare measurements and their differences among the two production systems. This issue is further followed up in Chapter 5.2.2.2.2.

83 percent of these livestock-keepers that live in areas where some arable land exists and hence, where crop production is potentially possible prefer strong offspring

$(Pr(ß>0)=\Phi(0,0.37,0.38))$ (coded: 1 = arable land available; 0 = not available). Likewise, the majority of people without the possibility to add crop production to their livelihood dislike the attribute "strong offspring" in bulls, and only 17 percent of this group liked it.

The availability of arable land also influences the preference for the attribute "traction"[93]. 97 percent of livestock-keepers with arable land chose their bulls due to their traction suitability and only three percent of livestock-keepers in areas where no crop production is feasible derive positive utility from traction suitable bulls. This outcome is well reasonable because pure pastoralists usually have no need for draught bulls. They only keep bulls for reproduction in their herds.

There is a great difference between the parameters on the production system for bulls and cows that significantly have an impact on livestock-keepers' preference for attributes. For cows, the source of heterogeneity among livestock-keepers is not as much a matter of their land use and how they manage their cattle, but more a matter of constraints (such as access to market and availability of arable land) the region and the environment place on their situation. For bulls, on the other hand, the most influential parameter is the production system *per se* (pastoralism or agro-pastoralism) and the question of complete sedentarisation.

5.1.2.2.3. WTP differences among production systems

As already mentioned, the change in land use and preferred production strains is one major factor influencing livestock-keepers in their choices concerning cattle attributes and breeds. The previously shown results of the MXL model with production system specific variables (see Table 18) give rise to the assumption that some of the cattle attributes vary with the type of production system the respondents are operating in. Therefore, separate models will be estimated: one built around respondents who are pastoralists and one including respondents who live on agro-pastoralism. This step allows differences in the WTP for attributes among the two groups of livestock-keepers to be revealed.

After having a closer look at the **bull** model (see Table 19), it is safe to say that in case of the pooled data set, agro-pastoralists assign significant importance to more attributes than pastoralists do. Agro-pastoralists find the conditions of the horns important when purchasing bulls, as well as to body size. These three attributes, all reflecting cultural values of cattle, did not influence pastoralists' decision making. This result is rather surprising because it was expected that pastoralists would indeed place positive values on the cultural traits and make

[93] $Pr(ß>0)=\Phi(0,0.89,0.46)$

their purchasing decisions according to them. On the other hand, agro-pastoralist's utility from bulls varies with horn conditions because of the use of bull for ploughing. The horns seem to determine how well bulls were suitable for traction. It was mainly a question of how well yokes and ploughs could be fixed on bulls. Long horns are thereby not preferred, with agro-pastoralists showing a negative WTP of -€15. Straight and short horns are also not favourable, showing a negative WTP of -€10. Hence, agro-pastoralists derive the highest utility from short and curved horns. As has already been explained, straight horns, although of short size, can cause injuries in mating and ploughing activities. Pastoralists were indifferent towards the body size, while, on the contrary, agro-pastoralists prefer large-framed bulls over small-framed ones (WTP of €8). The most important finding is related to the water frequency. Agro-pastoralists in Kenya, in Ethiopia and overall are indifferent towards the attribute "watering once in 3 days" compared to the baseline of "watering once in 2 days", while pastoralists in all cases strongly prefer bulls that require water only once in three days (WTP in Ethiopia: €38, in Kenya: €27, overall: €32). Bulls that need to be tracked to a water point once a day or need permanent surplus water are not preferred in all cases, by pastoralists and agro-pastoralists alike. Due to the partial sedentarisation of agro-pastoralists near permanent artificial water points, it is not surprising that their cattle do not need to be very adaptive anymore, unlike the cattle kept by pure pastoralists. "Tick tolerance" was a favourable attribute for pastoralists and agro-pastoralists but pastoralists are willing to pay €9 more for this trait (€29 to €20). Pastoralists also show a higher WTP for bulls producing strong offspring, namely €7 more per bull (€26 to €19). For the attribute "traction suitability, not surprisingly, agro-pastoralists are willing to pay more than double for this attribute than pastoralists would pay (€57 to €25). The IV, combining all attributes, as similar for both groups of livestock-keepers (€240 and €235).

Kenyan agro-pastoralists, though, show exclusive behaviour. Their utility from bulls is only determined by three attributes, namely the productive traits "traction suitability" (WTP of €62) and "strong offspring" (WTP of €25). The only adaptive trait considered when purchasing bulls, is "watering once a day" with a medium aversion for it (WTP of -€26). Kenyan pastoralists, on the contrary, prefer highly adaptive bulls (WTP for "wat_3" of €27 and WTP for tick tolerant bulls of €22). Pastoralists also feel a stronger aversion towards the attribute "watering once a day" with a negative WTP of -€82 and hence €54 less than for agro-pastoralists. Cultural traits seem to be of no importance to Kenyan agro-pastoralists and pastoralists alike (confirming the country-specific results of Table 9 and 10). No WTP for the attribute "body size" and "horns" could be detected for both groups because this attribute is not significant. The IV is slightly higher for pastoralists than for agro-pastoralists (€270 to €218).

Table 19: Taste differences in different production systems for bulls (WTP measures in €)

	Ethiopia		Kenya		all	
Attribute	**Pastoral system**	**Agro-pas. system**	**Pastoral system**	**Agro-pas. system**	**Pastoral system**	**Agro-pas. system**
Watering every day	-45	-67	-82	-26	-65	-59
Watering once in 3 days	38	not sign.	27	not sign.	32	not sign.
Tick tolerance	29	26	22	not sign.	29	20
Big body size	not sign.	8	not sign.	not sign.	not sign.	8
Strong offspring	16	17	25	25	26	19
Traction suitability	38	52	14	62	25	57
Short and straight horns	not sign.	-9*	not sign.	not sign.	not sign.	-10
Long and curved horns	not sign.	-16	not sign.	not sign.	not sign.	-15
No of observations	369	1809	666	432	1035	2241
CS	183	233	270	218	240	235

All values are significant at the 95% confidence level, but * = significant at 90% confidence level

Ethiopian agro-pastoralists value cultural attributes of bulls. Their WTP for large-framed bulls amounted to €8, while Ethiopian pastoralists are indifferent towards this attribute. Furthermore, Ethiopian agro-pastoralists seem to be in favour of “short and straight” horns with negative WTP for long horns (WTP of -€16) and also for “short and curved horns” (WTP of -€9). This is again related to the better use for traction. The WTP for traction suitable bulls is €14 higher for Ethiopian agro-pastoralists than for pastoralists (€52 to €38) while the WTP for “tick tolerance” (€29 for pastoralists and €26 for agro-pastoralists) and “strong offspring” are roughly the same (€16 for pastoralists and €17 for agro-pastoralists). The IVs differ largely, amounting to €183 for pastoralists and €233 for agro-pastoralists.

Table 20 exhibits the WTP indicators for **cow** attributes. Looking at the pooled data set, it is clear that agro-pastoralists assign more value or utility to cows conceiving one calf every year rather than every two years; i.e. the agro-pastoralists’ WTP for this attribute exceeds the pastoralists’ WTP for it by €6 per cow. A dissimilar situation applies for the attribute “tick tolerance”: for pastoralists, this attribute has an €8 greater value per animal than for agro-pastoralists (WTP of €22 for pastoralists and WTP of €14 for agro-pastoralists). For the adaptive attribute “watering once in 3 days”, pastoralists are also willing to pay more, to be precise, €6 more than agro-pastoralists (WTP of €14 to WTP of €8). The WTP amounts to exactly the same for the attribute “0-2 litres daily milk yield per cow” (-€10). “Horns” and a milk yield higher than four litres are not significant for agro-pastoralists and pastoralists alike.

Table 20: Taste differences in different production systems for cows (WTP measures in €)

	Ethiopia		Kenya		all	
Attribute	**Pastoral system**	**Agro-pas. system**	**Pastoral system**	**Agro-pas. system**	**Pastoral system**	**Agro-pas. system**
Watering every day	-26	-33	-58	-21	-48	-31
Watering once in 3 days	15	10	18	not sign.	14	8
Tick tolerance	12	17	28	8	22	14
Big body size	not sign.	5	not sign.	17	not sign.	9
One calf per year	12	17	9	9	12	18
0-2 litres milk per day	not sign.	not sign.	-17	-24	-10	-10
> 4 litres milk per day	not sign.	not sign.	not sign.	not sign.	not sign.	not sign.
Short and straight horns	not sign.	not sign.	not sign.	not sign.	not sign.	not sign.
Long and curved horns	-6	-5	not sign.	-11	not sign.	not sign.
No of observations	504	2424	888	600	1392	3024
CS	89	104	182	152	153	117

All values are significant at the 95% confidence level

Continuing with Kenyan livestock-keepers, it was most striking that agro-pastoralists do not positively value the attribute "watering once in 3 days". The same result was found for the Kenyan bull model and can be explained by the changed production system with sedentary cattle herds. On the other hand, Kenyan agro-pastoralists assign significant value to the body size with a WTP of €17 for it. In contrast, Kenyan pastoralists are indifferent towards the body size of cows. The difference between bulls and cows is noteworthy. Kenyan pastoralists do not derive any benefit from large-framed bulls, but from big sized cows. While Kenyan agro-pastoralists are also indifferent to the level of tick tolerance of bulls, they do show a positive WTP for tick tolerant cows (€8). The WTP for the same attribute was €20 higher for Kenyan pastoralists (WTP of €28). Both, Kenyan agro-pastoralists and pastoralists derive negative utility from a low milk yield of "0-2 litres", although agro-pastoralists' WTP is even lower by €7 (WTP of -€17 for pastoralists and WTP of -€24 for agro-pastoralists). The IV of Kenyan pastoralists exceeds the one of agro-pastoralists by €30 per cow (€182 compared to €152).

The Ethiopian agro-pastoralists' and pastoralists' preferences are quite similar, except for the preference for the attribute "body size". The same indifference of pastoralists towards the body size for bulls applies for cows as well. Ethiopian agro-pastoralists, in contrast, assign a WTP of €5 for large-framed cows, that is €12 less per cows than Kenyan agro-pastoralists would be willing to pay for it. In Ethiopia, agro-pastoralists display the higher WTP for the adaptive attribute "tick tolerance" (WTP of €17 for agro-pastoralists and WTP of €12 for pastoralists). In Kenya and in the pooled data model, pastoralists show higher WTP for tick tolerant cows and, also in case of bulls, pastoralists' WTP always exceeds agro-pastoralists' WTP for it. This variation of the taste for tick tolerance is not surprising given the fact that pastoralists need to track their herds long distances in bushy rangelands that are heavily infested by ticks. Finally, unlike Kenyan agro-pastoralists, agro-pastoralists in Ethiopia also derive higher benefits from cows that are able to withstand water shortage up to three days, although the Ethiopian agro-pastoralists' WTP for this attribute is not as strong as the pastoralists' WTP for it (WTP of €15 for pastoralists and WTP of €10 for agro-pastoralists). Ethiopian pastoralists show a €15 lower CS for one cow than Ethiopian agro-pastoralists (€89 compared to €104).

The comparison of taste variation among individuals in the two production systems and in country-specific comparison reveals various crucial points that can be summarised as follows:

- Agro-pastoralists considered the ability to withstand water shortage for up to three days for bulls as an unimportant trait
- Agro-pastoralists considered the ability to withstand water shortage for up to three days for cows less important than pastoralists did
- Agro-pastoralists and pastoralists were equally indifferent towards the attributes "> 4 litres milk yield" and "short and straight horns" in cows
- Agro-pastoralists preferred "short and curved horns" whereas pastoralists were totally indifferent towards the size and the shape of horns of bulls.
- Only agro-pastoralists showed positive WTP for large-framed animals, whereas pastoralists' preferences were not driven by the body size, neither of bulls nor of cows
- Kenyan livestock-keepers (pastoralists and agro-pastoralists alike) were indifferent towards cultural values of bulls (body size and horns)
- Agro-pastoralists in Kenya mainly considered productive traits as purchase criteria for bulls
- Kenyan and Ethiopian agro-pastoralists showed large differences in their utility pattern for cows and bulls, whereas pastoralists in both countries showed similar preferences and WTP indicators

5.2. The value of cattle breeds

Unlike the first part of the analysis that aimed to answer the question of whether or not local cattle breeds possess unique attributes that justify their conservation and that gives them unique breeding values, this second set of results of the MNL model seeks to infer from the knowledge about the value of attributes to the **net value** of **entire cattle breeds.** Thereby, special focus is placed on the Borana breed since the immense degradation of its genetic material has been already revealed (see Chapter 3). The underlying approach is entirely based on the results of the conducted CE. These hitherto presented results (see Chapter 5.2) reflect the livestock-keepers preferences for local cattle attributes but, since the CE was designed in an unlabeled way (see Chapter 4), no consequences can be drawn as to breeds. Inferring from this generic approach to a **breed-specific view** requires the application of **simulations of scenarios** in LIMDEP 8.0 Nlogit 3 (Greene, 2003b). The model framework is the same as for the basic MNL model and can be gleaned in Chapter 2.4.1.

First of all, the theory behind so called **“What-if” scenarios** will be explained before proceeding with the description of the scenarios. A scenario in this context resembles one breed or Borana subtypes in their combinations of attributes. This combination is purely theoretical, but best describes a breed based on livestock-keepers opinions and knowledge of cattle breeds. Finally, the results for all scenarios (i.e. breeds) will be exposed and differences in results for livestock-keepers in different **production systems** will be highlighted. The selected welfare measures for livestock-keepers from different breeds in this context are the values of COS (see Chapter 2.3.2). Their discussion forms the concluding part of this section.

5.2.1. Theory of “What-if” scenarios

Following the implication of COS as preferred welfare measure, COS will be estimated using “what-if” scenarios. When applying “What-if” scenarios, the researcher is interested in **future choices** that will be made by livestock-keepers when only the choice sets (the supplied attributes and levels) change and the livestock-keepers preference maximising behaviour remains unchanged. In these kinds of scenarios, a range of possible levels of each attributes represents the likely domain in which each attribute will reside and a distribution of forecasted choice shares are derived (Hensher et al., 2005, p. 452). In terms of the “what-if” scenarios, COS represents the welfare change when shifting from the initial situation (in this case from the results of the MNL model where livestock-keepers could chose the alternatives with their most preferred attribute levels) to the newly created scenario where the attributes and levels are **fix**. With these fixed attribute levels, a **hypothetical animal profile** that resembles a **distinct breed** is created in each scenario. The scenarios then shed light on the difference between the actual made choices and the new choice task where livestock-keepers are hypothetically confronted with labelled alternatives.

The assumption thereby is that livestock-keepers behave according to their previous utility maximisation and hence their changes in WTP values are only due to the change in the choice sets. Hence, the same choice probabilities that were derived from the basic MNL model (see Chapter 5.2) in a first step are assumed to apply for the scenarios as well. The changes of attributes were restricted to the three animal alternatives (animal A, B and C) out of a choice set, i.e. no change was made in the opt-out alternative.

5.2.2. Scenario settings

The research area depicted in Figure 3 in Chapter 4 can be divided into areas of different breed presence. The villages were selected in such a way for the interviews in order to have a great variance of different subtypes of the Borana breed in order to derive an exact overall value for this breed. As can be seen on the map in Chapter 4, only the OB is existent in both countries, Kenya and in Ethiopia; whereas only southern Ethiopia is home to the EB subtype and North and North-East Kenya is home to SB. In Kenya, around Kijiji, the prevailing breed was found to be a crossbreed of Borana and a local Small East African Zebu (SEAZ). Similar SEAZ/Borana crosses are dominant in one research area in Ethiopia, namely around Finchawa. There, these crosses were most commonly formed by any type of Borana and a local breed called Guji. In order to avoid complications, all small-framed local Zebu cattle in the research area were pooled into SEAZ. In short the prevalent Borana subtypes, Borana crosses and other breeds amount to five: OB, EB, SB, Borana/local breed crosses ("Cross") and SEAZ.

However, for this analysis, this list has been extended by two breeds/crosses that are currently not being kept in the research area but which are well known among livestock-keepers and which are, due to increasing market activities and linkages, about to be transferred into the research area. These two types are the improved KB (see Chapter 3 for more details) and an admixture of Borana and exotic breeds ("Exotic"). The latter crossbred has not been found to be in the possession of any livestock-keeper in the Ethiopian research area, but in the Kenyan research area clear impetus towards the introduction of those types of crosses was exposed and, to some extent, exotic genetic material has already been brought from Nairobi markets to northern Kenya. Even though the crosses of Borana and exotic breeds and the improved KB were not found in the research area, and hence no utility assessment was carried out (in terms of CEs), a comparison of these two types relative to the other Borana subtypes was possible because a hypothetical market setting was created. In this hypothetical market setting (=scenario) their utility to livestock-keepers in the research area can be derived based on the results from the stated preference analysis (the CE) where livestock-keepers valued different cattle attributes (see Chapter 5.2).

Table 21: Scenario settings for simulation processes

Attribute	Fix at new value						
	OB	**EB**	**SB**	**KB**	**Cross**	**SEAZ**	**Exotic**
Price	100%	110%	120%	130%	90%	80%	150%
Water requirement once a day	-1	-1	-1	-1	-1	-1	1
Water requirement once in 3 days	1	1	1	-1	1	-1	-1
Big body	-1	1	1	1	-1	-1	1
Tick tolerant	1	1	1	-1	-1	-1	-1
Long and curved horns	-1	-1	-1	-1	-	1	-
Short and straight horns	1	1	1	-1	-	-1	-
Annual calving frequency/strong offspring	1	1	1	1	1	-1	1
0-2 litre daily milk yield	1	-1	-1	-1	1	1	-1
> 4 litres daily milk yield	-1	-1	-1	1	-1	-1	1
Traction suitable	1	1	-1	-1	1	-1	-1

The attributes that were initially chosen for the animal profiles used in the CE were also the ones characterising the seven breeds/subtypes through different attributes levels. The appropriate attribute levels for each breed/Borana subtype were elicited from interviews with livestock-keepers and, only in very few cases where livestock-keepers could not give a clear statement on a certain attribute expression (level) of a breed was the missing data obtained from the DAGRIS database (ILRI, 2006a). Eventually, seven hypothetical animal profiles were created, each representing one of the abovementioned breeds and subtypes. They are presented in Table 21. Note that for cows livestock-keepers expressed indifferent preference for horn appearance and hence the two attributes "long and curved horns" and "short and straight horns" were not considered in the scenario settings, although the horn appearance differ a lot from breed to breed. Likewise, for the country-specific models, attributes which exhibited insignificant coefficients in the basic MNL model (see Tables 7 and 8) were dismissed for the scenarios as well.

In the case of Borana admixtures and exotic breeds, the attribute "horn size and shape" was not set at a fix value because most of the exotic breeds are polled and when they are horned the horn condition does not play an important role because calves are usually dehorned anyway (horns are most commonly removed at the age of 4 to 12 weeks (in intensive production systems)). The same applies for Borana crosses with other local breeds. Here, the horn appearance can take on any parameter value and hence this attribute is not set as fix value but behaves as if being determined by the utility maximisation of livestock-keepers, i.e. as in the basic MNL model.

"What-if" scenarios are created as described above and by simulating changes in attributes and their levels possible impact upon the choice probabilities of livestock-keepers can be revealed. It is noteworthy that the attribute "price" was adjusted as well because the different breeds clearly achieve distinctive prices on the local markets and it would be unrealistic to leave the price attribute at its initial level. The indices are attribute-based values and are calculated on the basis of hypothetical settings, assuming that livestock-keepers always show the same preferences than they showed when facing the choice sets.

Those scenarios, not taking insignificant attributes into account (see subsequent section), might not differ a lot between breeds because there a only a few attributes left that could vary, meaning that livestock-keepers almost have the same utility for various breeds. The live-stock keepers are hence not very worse-off or better-off when switching breeds/subtypes and cannot ask for much compensation.

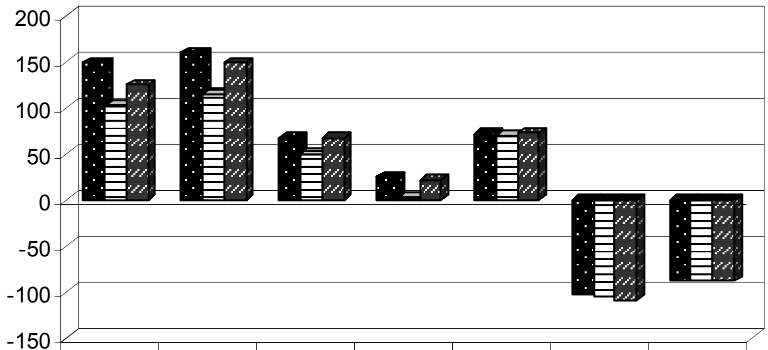
This approach of creating scenarios is arguable and bears some **limitations** especially when taking into account the broad and diffuse definition of a "breed" in developing countries. It has to be made clear that the scenarios are based on descriptions of breeds from the point of view of local livestock-keepers. They might be therefore a bit **arbitrary** and might not match with other livestock-keepers' opinion in other areas of Kenyan and Ethiopia. The local people and communities in the research area will eventually be involved in conservation programmes for the Borana and hence it is important to respect and consider their opinions and traditional knowledge on cattle production.

5.2.3. Changes in compensating surplus

As a first step, the change from the initial situation in which livestock-keepers maintain their current breed to a new situation in which one of the simulated breeds/subtypes should be maintained was calculated using LIMDEP Nlogit 3.0 (Greene, 2003b). This difference, expressed in €, is the COS that livestock-keepers will obtain when shifting to the new breed for which the utility for them was simulated with the help of the scenarios. It is worth mentioning that the initial situation from which a change will be calculated is derived from the results of the basic MNL model (see Tables 1 and 2). Hence, all attributes that were found to be insignificant in the basic model and not to have any impact on the purchase behaviour for cattle were dismissed, in the "what-if" scenarios as well. In Figures 4 and 5 the signs of the COS for cows and bulls for the relevant breeds/subtype are displayed.

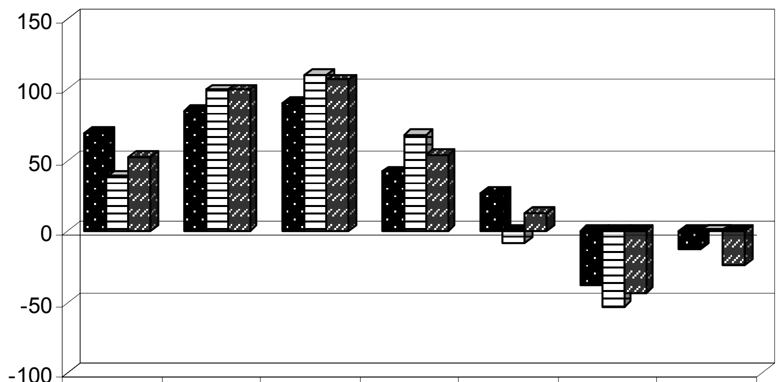
The negative estimated COS of, for instance, -€108 for SEAZ bulls for the pooled data set implies that when maintaining SEAZ bulls, livestock-keepers would face a €108 lower utility compared to the base (status quo[94]) utility of €239, i.e. the utility they derive from one SEAZ bull just amounts to €131 (€239 - €108 = €131). In other words, the €131 are regarded as the monetary value of one SEAZ bull. Livestock-keepers derive utility worth of only €90 (down from the base of €134) per SEAZ cow (for the pooled data set). They obtain lower utility than initially stated as base for SEAZ cattle and exotic cattle. For all other hypothetical breeds livestock-keepers derive higher utilities than the status quo.

Figure 4: Compensating surplus for different breeds of bulls in Kenya and Ethiopia (in €)



	OB	EB	SB	KB	Cross	Zebu	Exotic
Ethiopia	149	160	67	25	71	-103	-88
Kenya	103	116	50	3	69	-105	-88
Pooled	125	149	67	21	73	-108	-88

Figure 5: Compensating surplus for different breeds for cows in Kenya and Ethiopia (in €)



	OB	EB	SB	KB	Cross	Zebu	Exotic
Ethiopia	69	85	91	42	27	-38	-12
Kenya	38	100	111	68	-8	-53	1
Pooled	52	100	107	54	13	-44	-24

[94] The meaning of status quo here is the base situation (the selected attributes and levels from the choice sets) for which livestock-keepers initially found maximal utility.

The main implication from calculating the COS for the different scenarios is that by means of them the values of breeds can be compared. Although the values of breeds are of a purely theoretical nature, as they are obtained from the scenario discussion, they provide a good proxy for the value of different breeds for livestock-keepers in the research area. The absolute values of breeds can be calculated by adding up the IVs of the status quo breed and the COSs. However, the differences between the breeds, namely the differences in the COSs, are more important, revealing the values relative to each other. The absolute values of breeds are as given in the subsequent table.

Table 22: Country specific monetary values (in €) of breeds - derived from the simulations

	Bulls		Cows		Pooled	
Breed	**Ethiopia**	**Kenya**	**Ethiopia**	**Kenya**	**Cows**	**Bulls**
OB	372	362	170	208	186	364
EB	383	375	186	270	234	388
SB	290	309	192	281	241	306
KB	248	262	143	238	188	260
Crosses	294	328	128	162	147	312
SEAZ	120	154	63	117	90	131
Exotic	135	171	89	171	110	151

The results for the country-specific data set for bulls of all breeds are in line with the pooled data set but a wide country-specific discrepancy of the COS for cows for some breeds is revealed. Ethiopian livestock-keepers, for instance, assign additional €27 to utility for Borana crosses, resulting in a value of crossbred cows amounting to €128 (€101 + €27 = €128). In Kenya, on the other hand, livestock-keepers seem to derive less utility from crosses than from the base situation, namely €8 less and hence €162 (€170 - €8 = €162). Ethiopian livestock-keepers also assign less value to Borana/Exotic crosses, namely €12 less than the €101 initial base and therefore only €89. Kenyan livestock-keepers, on the other hand, obtain utility worth of €171 from each Borana/Exotic cow, and that is €1 more than they assigned to the base value. For all breeds, the absolute values exceed the average market price for cattle in local markets[95]. Only the absolute estimated values for SEAZ almost perfectly match the average market prices.

[95] As shown in Chapter 4.2.1, the average market price for bulls in Kenya was €137.5, in Ethiopia €120 and for the pooled data set €128.75. The average price that a cow in Kenya achieved was found to be €112.5, in Ethiopia €60 and therefore in average €86.25 (pooled data). The data on market prices were collected in local markets.

So far, the values were all assessed separately for bulls and cows but when deciding conservation priorities (see Chapter 7), it is more important to quantify the **average value** for one animal, no matter which sex. The most preferred ratio for livestock-keepers is assumed to be one breeding bull per nine cows. This ratio also reflexes the average herding size of 10 animals. The average value for every breed is expressed in the subsequent table.

Table 23: Country specific monetary values (in €) of breeds – averaged over sex

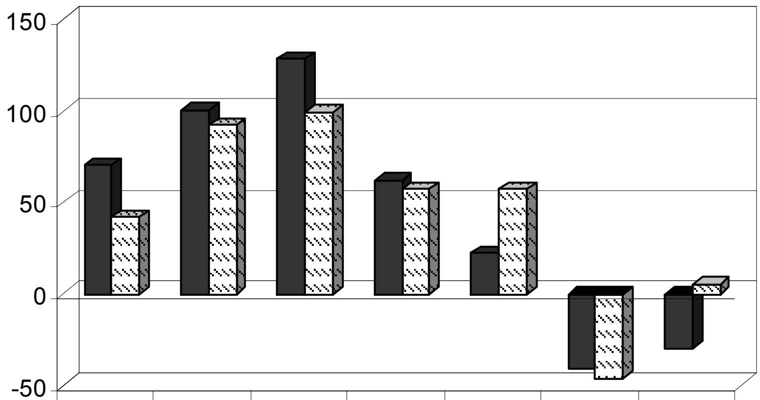
	Ethiopia	Kenya	Pooled
OB	190	223	204
EB	**206**	281	**249**
SB	202	**284**	**248**
KB	154	240	195
Crosses	145	179	164
SEAZ	69	121	94
Exotic	94	171	114

In Kenya, SB was the breed that was valued the highest (€284), while in Ethiopia it was the EB (€206). Breeds were in general higher valued in Kenya that in Ethiopia but that is partly due to the higher overall WTP by Kenyan livestock-keepers (the higher IVs). Investigating the pooled data set showed that the monetary value for EB and SB was almost the same.

5.2.3.1. Different welfare changes among production systems

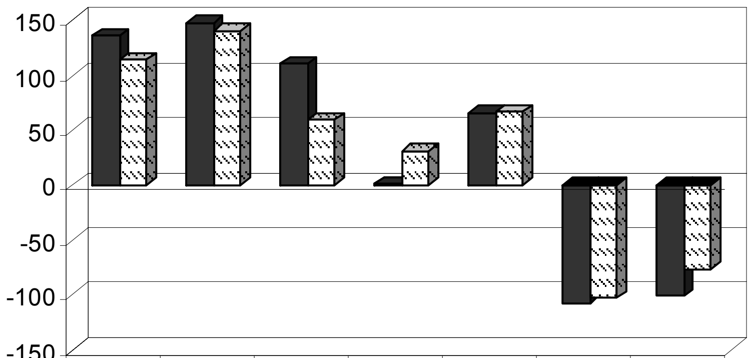
Following the findings of livestock-keepers' heterogeneity among attribute preferences between different production systems (see Chapter 5.2.2.2.2), this sector addresses the question whether the costs of substitution are the same for **pastoralists** and **agro-pastoralists**. This question should be posed because it helps to decide which **group of livestock-keepers** has which utility from which breed/subtype. The following two graphs (Figure 6 for cows and Figure 7 for bulls) depict whether the value of different breeds is higher or lower compared to the status quo for agro-pastoralists and pastoralists.

Figure 6: Compensating surplus for different breeds of cows in different production systems (in €)



	OB	EB	SB	KB	Cross	Zebu	Exotic
Past.	70	100	128	62	22	-41	-30
Agro.	42	92	99	57	57	-46	5

Figure 7: Compensating surplus for different breeds of bulls in different production systems (in €)



	OB	EB	SB	KB	Cross	Zebu	Exotic
Past.	136	148	110	1	66	-108	-101
Agro.	114	141	59	31	67	-103	-77

A large discrepancy can be revealed for exotic breeds. Livestock-keepers pursuing a pastoral life derive negative utility from exotic cows while livestock-keepers in agricultural production systems derive positive utility from them, even if the utility is very little (€5). The discrepancy for exotic bulls is equally large (-€101 to -€77) but, at least, in both production systems livestock-keepers would derive negative utility from exotic bulls. All other breeds expose the same signs, even though with large differences in CS values between the two production systems. Apart from exotic breed admixtures, keeping only SEAZ results in lower utility than the initial maximum utility from cattle production would be for both agro-pastoralists and pastoralists alike. The subsequent table (Table 24) provides the absolute values (utilities) for different breeds as simulated perceptions of local livestock-keepers.

Table 25 shows the weighted average value for one animal (weighted 9 to 1 for cows to bulls).

Table 24: Production system specific monetary values (in €) of breeds - derived from the simulation process

Breed	Bulls		Cows	
	Agro.	Past.	Agro.	Past.
OB	349	376	163	230
EB	376	388	213	260
SB	294	350	220	288
KB	266	241	178	222
Crosses	302	306	178	182
SEAZ	132	132	75	119
Exotic	158	139	126	130

Table 25: Production system specific monetary values (in €) of breeds – averaged over sex

Breed	Agro.	Past.
OB	182	245
EB	**229**	273
SB	227	**294**
KB	187	224
Crosses	190	194
SEAZ	81	120
Exotic	129	131

Table 25 shows that pastoralists assign higher values to one animal of every breed except for exotic admixtures. The difference between pastoralists and agro-pastoralists regarding the value for crosses is very low (difference of €4), though. For agro-pastoralists no big discrepancy can be detected for EB and SB while for pastoralists SB is the most valuable breed, followed by EB and OB. Similar to the results of the country-specific models, the simulated values are higher than the average market values for bulls (app. €129) and cows (app. €86) for all simulated breeds. Only for SEAZ dies the simulated value nearly correspond to the average market prices.

5.3. *Implications for conservation and breeding*

For **breeders**, the values of attributes as well as for breeds are both relevant, as they are interested in calculating the total merit of a breed that they would select for a breeding programme. Breeders already use markers and gene mapping to identify "valuable" genes for which a breed should be selected for breeding. That is particularly relevant for traits that are controlled by one or very few loci, such as the presence or absence of horns and coat colour in cattle (Cunningham, 2005, p. 45). In such cases, it is already possible (as it even was before the advent of molecular methods) to determine the genotype and with this information to improve breeding programmes and to assist selection programmes. With the introduction of molecular methods, individuals can be characterised for additional traits, such as double muscling in cattle, meat quality in pigs etc. (Cunningham, 2005, p. 45). In the future, as it would have immense relevance for animal production in developing countries and in particularly production in harsh environments, breeders might be able to detect single genes that cause the expression of adaptive and cultural traits[96] and then they could make use of the monetary component of the trait, as estimated by using a CE. Also in case of cultural traits, using the knowledge of monetary values for breeding programmes can make selection possible for traits that formerly would not have played an important role in breeding objectives.

Conservationists are more likely to be concerned about "which" of the local livestock-keepers to target for participating in conservation programmes in order to make it successful and obviously to conserve the "most valuable" breed. Further useful implications can be derived for action-taking in drought situations. Instead of hasty and imprudent restocking of the herds by the distribution of inferior Highland Zebus (see Chapter 3.3.4) to livestock-keepers, a more appropriate policy would be to first monetarily compensate livestock-keepers for their losses and then to built up a breeding scheme with those Borana animals that survived the drought. The compensation should thereby reflect the value of the breed that livestock-keepers have lost to the drought and as a proxy the IVs derived in this Chapter (see Table 5 in Chapter 5.2.1.3) can be taken guiding policy-makers in their decisions. For instance, livestock-keepers in Kenya can be granted a single payment of €259 for bulls and €170 for cows, in Ethiopia €223 per bull and €101 per cow. These monetary values reflect the utility that livestock-keepers in the research area derive per cow or per bull, no matter of the breed. Of course, many other factors need to be taken into account when it comes to feasible mechanism for compensating livestock-keepers but research in the field of restocking, insurance mechanisms and compensation payments in times of catastrophes is still in its

[96] This is still difficult because usually more than one gene affects a given trait, known under multiple loci or multiple gene effects. In fact, many traits are controlled by an unknown number of genes and loci. Further, probably every gene is pleiotropic to some extent (that is when one locus (gene) influences more than one trait within a given individual). A lot of research is currently being done in the field of finding these quantitative trait loci (QTL) by using microsatellite markers. The objective lies in identify markers closely linked to a functional gene or QTL (Cunningham, 2005, p. 46).

infancy. Relating compensation payments to the utility that livestock-keepers loose by losing animals constitutes a nice proxy for "fair" compensation.

5.3.1. Targeting livestock-keepers

The economic analysis as presented in Chapter 5.2.2 (the application of a MXL model) sheds light on changing preferences among livestock-keepers with different socio-economic background. This gives a first idea, grounded on economic theory and empirical data, whether taste heterogeneity for cattle can be detected. Knowing the distribution of this taste variation helps to set up conservation programmes in the "right" research area and among the "right" livestock-keepers.

The initial objective of this research was to create a "**hypothetical livestock-keepe**r" with socio-economic characteristics set to the mean or modal values of the individuals in the dataset and set to those values at which the characteristics seemed to have impact on the preference for cattle attributes. This "hypothetical livestock-keeper" would have facilitated the targeting of participants for conservation programmes for Borana cattle, namely targeting those who derive the highest utility from the pure Borana and hence whose participation would have been most cost-efficient. However, due to the lack of socio-economic characteristics having any impact on the preference for cattle attributes, this objective was eventually not pursued.

Tables 26 and 27 provide the individual-specific parameters of livestock-keepers influencing the preference for bulls and cows. These findings are based on the MXL with individual characteristics randomly distributed among attributes and, with it, the detection of the source of heterogeneity among livestock-keepers (see Tables 17 and 18). With the provision of these parameters, it can be inferred which group of livestock-keepers would derive the highest benefit from keeping cattle with special traits.

The results of the second MXL model (Table 18) offer evidence, that livestock-keepers living in pure pastoral systems were most likely to show a high WTP for well adaptive **bulls**, i.e. bulls expressing the attributes "watering once in 3 days" and "tick tolerance" but also for bulls that provide strong offspring. Vice versa, agro-pastoralists were less likely to be willing to pay much for bulls that can withstand water shortage for up to three days, that are tolerant to ticks and that provide strong offspring (see Table 26). This result is very important with respect to conservation initiatives because the pure Borana breed expresses exactly these traits that are preferred by pastoralists, i.e. for which pastoralist are willing to pay. Hence, asking pastoralists to participate in conservation programmes for the pure Borana bulls seems to be very promising and not costly because pastoralist would gain utility from it. No compensation is required in this case, whereas when agro-pastoralists were to be asked to maintain pure Borana bulls with attributes that they do not prefer, compensation payments might be needed. In fact, the estimation of separate models for the two production systems (see Table 19) also offers evidence for a difference in WTP estimates for the attribute "watering once in 3 days", to be precise, pastoralists are willing to pay €32 per bull with this trait expression whereas agro-pastoralists' WTP amounts to zero. Agro-pastoralists were indifferent towards this attribute in bulls, i.e. they do not mind this trait but would not be willing to pay for its provision. The same evidence is given for tick tolerant bulls. Pastoralists would be willing to pay €9 more for this attribute than agro-pastoralists, with an even larger discrepancy (€22) when considering only the Kenyan data set (see Table 19).

Further, households with many members are also best to target for participation because larger households are more likely to place positive values on the adaptive attribute "tick tolerance", and the productive attributes "strong offspring" and "traction suitability", all attributes for which Borana bulls are well known.

The parameter "country" only plays a minor role, as it is only randomly distributed for the attribute "traction suitability". Ethiopian livestock-keepers were more likely to pay for traction suitable bulls but this finding has no strong implications for targeting livestock-keepers. One cannot infer from these results that Ethiopian livestock-keepers would be better (most cost-efficient) suited for particularly conserving pure Borana bulls than Kenyan livestock-keepers because many other local breeds are traction suitable as well; taking into account, however, the country-specific model (see Table 22) it can be stated that Ethiopian livestock-keepers would be willing to pay €10 more for traction suitable bulls than Kenyans would pay for it. The same situation applies for livestock-keepers with access to arable land. They were more likely to show higher WTP indicators for traction suitable bulls but no sound conservation implication can be drawn.

Livestock-keepers who preferred bulls that need water only once in three days were not only pastoralists but also individuals with high income. This is the only attribute that is determined by the level of income. Taking the mean income of €76 per year, 55 percent[97] of livestock-keepers with this income would prefer bulls showing this adaptive trait. Among livestock-keepers with an income of e.g. €350 per year, 72 percent[98] do prefer this attribute in bulls. The

[97] $Pr(ß>0)=\Phi(0,76*0.0012=0.09,0.71)$

[98] $Pr(ß>0)=\Phi(0,350*0.0012=0.42,0.71)$

preference for “wat_3” equalises when no income is generated[99]. In this case, 50 percent of livestock-keepers prefer bulls with “wat_3” while the other 50 percent dislike this attribute in bulls. Livestock-keepers with positive income per year show a proportion for positive utility from “wat_3” of more than 50 percent.

Table 26: Parameters influencing the preference for attributes in bulls

Attribute	Production system	Arable land	Country	Income	HH size
Wat_3	Pastoralism			High	
Tick	Pastoralism				Large
Traction		Yes	Ethiopia		Large
Offspring	Pastoralism				Large

Progressing with the **cow** model (Table 27), the productive trait “calving frequency” is determined by four parameters related to livestock-keepers’ background: livestock-keepers who live far from arable land, who have proper access to a market, who reside in Ethiopia and who are responsible for a large household size derive positive utility from an annual calving frequency. Among those livestock-keepers whose household comprises 6 members (the mean, see Chapter 4.3) 76 percent prefer an annual calving frequency while the other 24 percent prefer a biannual calving circle[100]. Many households, in fact, constitute of 10 or more members and with an increase with every member the percentage of individuals preferring cows that conceive one calf per year also increases. As a comparison, the separate models for Kenya and Ethiopia also correspond to this discrepancy in taste for the attribute “calving frequency”, suggesting that livestock-keepers in Ethiopia would be willing to pay €9 more than Kenyan individuals (see Table 23).

The highest utility from larger cows lies with livestock-keepers who are agro-pastoralists and who possess large herds. Among livestock-keepers with, for instance, the mean of 13 adult cattle, 69 percent like big cows while the other 13 percent prefer small-framed cows[101]. Among livestock-keepers with a large herd, e.g. amounting to 50 adult cattle, 97 percent prefer big bodies[102]. Livestock-keepers keeping the minimum amount of one animal (respondents without any cattle were not considered for interviews) express an ambivalent preference for the “body

[99] Pr(ß>0)=Φ(0,0,0.71)

[100] Pr(ß>0)=Φ(0,6*0.059=0.354,0.498)

[101] Pr(ß>0)=Φ(0,13*0.009=0.117,0.243)

[102] Pr(ß>0)=Φ(0,50*0.009=0.450,0.243)

size" in cows, with 52 percent of individuals preferring and 48 percent contemning large-framed cows[103].

Table 27: Parameters influencing the preference for attributes in cows

Attribute	Production system	Arable land	Market access	Herd size	Country	HH size
Wat_3						Large
Wat_1						Large
Milk_3						Large
Milk_1						Large
Calving		No	Yes		Ethiopia	Large
Big body	Agro-pastoralism			Large		

In conclusion, there are a few policy implications that can be derived from the heterogeneous preferences of livestock-keepers for cows and their attributes because not many socio-economic as well as production system related parameters were found to have a significant impact on the choice for cows. The attribute "calving frequency" is one attribute for which one can define a certain group of livestock-keepers who prefer annual and biannual calving rates. The Borana breed is well known for its strong fertility and the ability to "produce" one calf per year. In this regard, livestock-keepers who do not cultivate land, have market access, reside in Ethiopia and are responsible for large households are the group that have the highest utility from cows with an annual calving rate. The calving rate, nevertheless, depends largely on the season and production system and in droughts, for instance, livestock-keepers do not prefer calves in an annual frequency. It is therefore surprising that the parameter "production system" does not have a significant impact on the preference for the "calving frequency". The most important finding is that pure Borana cows with their large frame were mostly preferred by agro-pastoralists with large herd size and hence, this group of individuals would be the most willing to participate in conservation schemes. Pastoralists, on the contrary, might ask for compensation payments because they prefer cows of small size.

Better but contradicting implications can be drawn for the case of conserving pure Borana bulls because many individual parameters, above all the kind of production system, have significant impact on the livestock-keeper's preference for the pure Boranas' attributes. Pastoralists would be definitely the best group of livestock-keepers to target because they appreciate three attributes which pure Borana bulls possess anyway (tick tolerance, strong offspring and adaptability to water shortage). This outcome reveals the different role that bulls

[103] $Pr(\beta>0)=\Phi(0,0.009,0.243)$

and cows play in a herd and the large discrepancy of livestock-keepers' preferences for attributes in cows and in bulls that makes conservation efforts much more complicated.

The household size, with large households reflecting a high degree of embodying traditional lifestyles, was found to be the source for taste variation in many attributes, in bulls and cows alike. There are two main possible reasons why this is not the case with small households: firstly, the head of the household is quite young and the household is newly formed (i.e. just separated out of another household and gaining independency) or secondly, migration of young household members has occurred (either for attending higher schools in towns or seeking better job opportunities outside farming and herding). In both cases, involving small households in conservation programmes for the pure Borana cattle is not recommended because, according to the MNL and MXL model results, these household do not place strong values on Borana unique attributes.

5.4. Summary

The conservation of AnGRs and in particular of cattle in East Africa is the focus of this research and this chapter provided empirical evidence for the justification of conserving the pure Borana breed. Economic values of important attributes of cattle have long been missing and hitherto poorly defined but, in this chapter, the discrete choice analysis as an economic tool was introduced. By applying a stated choice analysis it was demonstrated that many values in form of attributes for which the Borana breed is well known (e.g. tick tolerance, resistant to water shortage, superior body size, cultural preponderance) were highly appreciated by local livestock-keepers. Knowledge about livestock-keepers' WTP for these attributes was gained and this is a first important step towards the formulation of policy implications for conservation initiatives for the Borana breed. Monetary values of distinct attributes can also be useful in determining breeding goals.

This chapter showed which attributes drive livestock-keepers' decision towards the purchase of cows and bulls. The results of the basic MNL model revealed that not all attributes that were hypothetically presented in the choice sets have equal significance on livestock-keepers' choices but that there were great differences between Kenyan and Ethiopian respondents. As an example, Kenyan livestock-keepers did not relate their utility from bulls and cows to cultural values, while Ethiopian livestock-keepers did not value productivity in cows as a very important factor.

As a result, the applied model exposed monetary values that livestock-keepers are willing to pay for these attributes that have significant impact on their choices. Again, the WTP values differ between the two focus countries but also show some matching values. It can be said that for bulls the attribute “traction suitability” prompt livestock-keepers to be willing to pay the highest amount and for cows the highest WTP were revealed for the attributes “annual calving rate” and “tick tolerance”. In the case of cows, livestock-keepers in both countries revealed the same indifference towards a high milk yield of more than four litres a day as well as for the cultural attribute “short and straight horns”. Cultural attributes of cattle, expressed as phenotypic appearance (such as body size and horn appearance) seemed not to play a very important role, in particular not in Kenya. The appearance of horns was found to be only significant for bulls but nor for cows. Ethiopian livestock-keepers seemed to be still very much driven by the traditional meaning of cattle and its attributes as a symbol of wealth and prospect. Adaptive traits, enabling cattle to withstand the harsh environmental conditions in the Borana lowlands, seemed to be of high importance to Ethiopian and Kenyan livestock-keepers alike, expressed by a high WTP for animals equipped with a high degree of adaptation. Kenyan and Ethiopian livestock-keepers showed a similarly strong aversion to animals that need water once a day (for bulls and cows), strengthening the fact that high-productive exotic breeds that are used to constant water supply would perish from water shortage when being kept in the Borana lowlands. Kenyan livestock-keepers appear to be more production-driven in their choices for attributes of cattle. In Kenya, with an increasing market pressure, livestock-keepers are eager to keep cows that give at least 2-4 litres milk per day whereas Ethiopian livestock-keepers do not mind low productivity of 0-2 litres milk per day per cow.

Having opted for a choice ranking approach, it was possible to derive separate WTP measures for the first and most preferred choice and the rejected choices. This step allowed eliciting additional information from choice sets that were dismissed as most preferred alternatives and hence do not lead to maximum utility for livestock-keepers. As a result, it was found that livestock-keepers significantly consider more attributes for their first choice whereby the last three choices were rather arbitrary, with only a few attributes possessing significant coefficients. Furthermore, the WTP values elicited from the most preferred choice are higher than those from the remaining choices. Only taking into account the first choice might lead to an overestimation of WTP indicators but with the inclusion of a ranking of alternatives they seem to be more “realistic”.

Besides the basic MNL model, a MXL model was specified to explore many of the unobserved portions of utility, usually found in discrete choice models, and that can improve the knowledge of livestock-keepers’ purchase behaviour for local cattle. By including individual taste parameters, the opportunity to target participants with similar tastes allows the launching of conservation strategies at a minimal cost level and a maximum success rate. Of highest interest is that many socio-economic parameters did not confirm any impact on livestock-keepers' decision making. The level of education, the cultural status within a village and the age of the head of household did not exhibit significant impacts on the preference for cattle attributes. The individuals' level of income contributed also very little to the taste variation for cattle attributes, whereas the parameters "household size", "country", "production system" and "herd size" indeed largely contributed to the explanation of the source of livestock-keepers' taste heterogeneity. These four parameters were set to randomly vary between individuals and choices because they seemed to have significant impact on the choice and utility of cattle.

These findings of the MXL model imply that there is indeed a great variation between preferences for cattle attributes among livestock-keepers in pure pastoral systems and those producing in agro-pastoral systems. The most striking result here, having adverse implications for the conservation of the pure Borana breed, is that pastoralists are indifferent towards the body size of cows and bulls. The pure Borana breed is known for its large frame but individuals in traditional pastoral systems seem not to place any importance on this cultural trait. The smaller subtypes of Borana have emerged in the course of continuous crossbreeding with small framed highland breeds, leading to genetic erosion of the pure Borana breed. The fact that pastoralists did not prefer big animals (and with it the pure Borana breed anymore) did not lead to halt this trend of crossbreeding.

The discrepancy in WTP values for adaptive traits, such as "tick tolerance" and "watering once in 3 days" is quite large with pastoralists showing a higher WTP than agro-pastoralists. Agro-pastoralists, on the other hand, are willing to pay more for productive traits such as "traction suitability" and "annual calving rate".

Regarding the net values of entire cattle breeds, this chapter amply showed how the simulation process according to Train (2003) can be used for simulating the predicted utility that livestock-keepers would assign to a certain combination of attributes. Breeds are known for their certain combinations of trait expressions and that is also in which they differ. Livestock-keepers in the research area know exactly which breed possess which attribute and, based on their statements, scenarios could be created and used for setting up the simulation process. The results of the simulation (see Table 23) clearly expose an exceeding value of EB and SB, followed by OB. The average value for one animal (no matter of sex) in Kenya and Ethiopia was found to be almost the same for EB and SB (€249 for EB and €248 for SB).

However, when looking separately at both countries, SB cattle seemed to outperform EB, KB and OB cattle in their utility in Kenya, while in Ethiopia, EB animals supplied the highest utilities to local livestock-keepers (before SB and OB). The utility perception for the KB subtype differed largely between both countries, with Kenyan livestock-keepers preferring KB over OB. This result is of importance for conservation and compensation mechanisms, underlining a growing interest of Kenyan livestock-keepers for improved breeds. The results for the different production systems reveal that pastoralists derived in almost every case higher utility than agro-pastoralists (see Table 25). Only for crosses did the utility seem to be equal.

The average market prices per animal sooner matched the value livestock-keepers placed on these admixtures. The value for EB, OB and SB might be overestimated, as well as the value of KB, or better, livestock-keepers would be willing to pay more for these subtypes than they actually did. The results for crosses, on the other hand astonishingly accurately fit the revealed average market price of cattle. Most of cattle traded in the market are of those crosses anyway and hence, the results show that the applied CE brings about reliable results. The overestimated values for EB, SB and OB can hence be treated as reliable because these breeds are in their pure form not available in the markets anymore (or at least very rarely) and hence the market price that livestock-keepers would actually pay for them cannot be detected in the market. No prior assumptions were made regarding the utility change that respondents face when ranking the animal-profiles and in theory they were allowed to state WTP and WTA values for certain attributes and breeds. The simulation process used upon the CE hence provides a nice approach in order to get an idea about the “real” net value of different Borana subtypes.

CHAPTER SIX

Costs of conserving the Borana breed

6. Costs of conserving the Borana breed

This chapter attempts to quantify the costs of conserving the pure Borana breed *in-situ*. The pure Borana is thereby defined by the **long-legged and large-framed EB** (or *Qorti* in local language). The underlying approach is based on the method of CV (see Chapter 2.5) for assessing costs of maintaining EB instead of the breed that interviewees actually keep. The costs in this case were elicited directly from livestock-keepers by asking their **WTA** compensation and can be understood as OC for substituting the current breed by EB. The outcome of the CVM will be elicited for Kenya and Ethiopia for cross-national comparison as well as for comparison of costs for conserving EB in different production systems.

Besides the results of the CVM, this chapter also gives a preliminary explanation on the importance and theoretical setting of costs analyses in conserving AnGRs. Furthermore it discusses the assessment of gross margins as an alternative approach to CVM with regard to its outcome and limitations.

6.1. The importance of cost-analysis for the efficient conservation of AnGRs

Due to the extreme competition for the scarce financial resources for the general development towards reducing poverty and eradicating hunger, a further issue needing to be discussed is the question concerning at which level AnGRs should be conserved and whether this should be done at any cost. Having an idea about costs of *in-situ* conservation and resulting identification of the most cost-efficient approaches can facilitate the decisions over **prioritising** the conservation of AnGRs. Explicitly including cost estimates into conservation prioritisation will probably alter conservation priorities because past studies suggest that cost does not correlate with biological value in any simple way (Balmford et al., 2000). Hence, striving to **maximise cost efficiency** is likely to increase the effectiveness of conservation planning (Ando et al., 1998).

In many countries the **financial resources** to enable a sustainable conservation of AnGRs are lacking, thus increasing the risk of AnGRs loss. The existing conservation activities demonstrate that there is an international and, in some cases, national process underway to address the threat of AnGRs erosion on the institutional as well as the practical level. Still, open questions remain, in particular concerning the cost-efficiency of AnGR conservation, and the answers to them will significantly determine the conservation efforts. In contrast to the research into the values and benefits of AnGRs, the costs of genetic resource conservation have received much **less attention** and fewer efforts have been made to quantify the costs connected to the conservation of AnGRs. Even if information on the costs of AnGRs conservation exists, it is rather vague in the majority of the developing countries. This holds true for the costs related to the *ex-situ* conservation activities, but far more for those related to *in-situ* conservation of AnGRs. Also, very few studies have been focusing on the costs of conservation programmes and the issue of cost-efficiency within conservation strategies.

Some assumptions came up but with little quantitative foundation and further empirical research is certainly needed. Simianer et al. (2003), for instance, assume that *in-situ* conservation is rather inexpensive and that with a minimum amount of funds endangered breeds can be maintained. Data on the actual costs of conservation are often difficult to find across broad regions of the world, and so proxies of cost such as area or human population density are more often used in priority-setting exercises (Balmford et al., 2001). A very large share of studies so far has been based on **complementarity methods** (Moore et al., 2004) and the costs of conservation are assumed to be due to **loss of value** and decreased production of marketable goods. They could thus be valued straightforward in monetary terms when market data is sufficiently available but in view of local breeds in marginal areas which possess various intangible values the costs must be derived in an alternative manner, for instance, by applying CVM and directly asking livestock-keepers.

With regard to this study, concerning the question of "**how"** the conservation can be best performed, it is also crucial to know the costs of a conservation programme. Since it is a common agreement that *in-situ* conservation is the best method for maintaining AnGRs (see Chapter 2.1) the cost analysis presented here only considers costs of *in-situ* conservation[104]. The question of "what" to conserve (see Chapter 5) also relates to the question of "how" and **"where"** to perform conservation programmes. The answers to these questions largely contribute to the amount of conservation costs which arise. For example, due to the mechanism of the founder affects (see Chapter 3.2.2) the question whether to conserve the same breed/subtype in different countries or whether it would be sufficient to conserve that breed only in one country arises. Installing a conservation programme in one country or even in a whole region clearly makes up for a large range of possible costs.

In the context of *in-situ* conservation, however, there are further strategies and decisions that have to be carefully decided on, considering possible benefits for less favoured households and small-scale agriculture and the society as a whole. Assessing the costs fosters the

[104] As the most recent drought 2005/06 in East Africa shows, only following *in-situ* conservation strategies might not be sufficient and costs should also be assessed for potential *ex-situ* strategies as they constitute an opportunity to minimise the risk of livestock losses due to catastrophes.

decision-making on conserving AnGRs and with respect to this study in particular the question of "**which Borana subtype"** should receive **priority in funding**. Chapter 7 will further explain the procedure of priority setting and the role of costs in this. Besides narrowing down the conservation to a certain subtype, namely the most cost-efficient one, the number of animals that should be conserved also determines the final costs of a conservation programme (see Chapter 7.3.4.1).

In literature four Borana subtypes are commonly mentioned and this notion is widely accepted. As already thoroughly brought up in Chapter 3.3, the four subtypes are EB, OB, SB and KB. A limited budget does not allow for all subtypes to be maintained. That would not only be very cost-inefficient but also unfeasible because then too many areas and local livestock keepers would be involved and hence transaction and operational costs would be immense, resulting in impossible future management of the conservation programme

6.2. Conceptualising the costs of in-situ conservation of AnGRs

Allocating the scarce financial resources between subtypes of Borana is particularly important for policy-makers to enhance **compensation payments** when necessary since livestock-keepers cannot afford to maintain local breeds on their farms just for the sake of animal diversity without considering their relative costs and benefits. Where specific breeds are of little direct economic interest to livestock-keepers but which society as a whole considers important enough to be maintained, the OC of maintaining local breeds can be taken as an indicator for the amount of **incentives** that might be needed to "persuade" livestock-keepers to carry on with one breed/subtype instead of introducing another local or even exotic breed. Distributing incentives (not only in form of money but also in form of drugs for animals, free veterinary services for local breeds etc.) might be the only way to prevent a replacement of indigenous breeds and hence an extinction of some genes. Furthermore, money based incentives (=**compensation payments**) also help to secure livestock-keepers' engagement in conservation initiatives for Borana cattle because one cannot expect livestock-keepers to forgo income by keeping poor productive breeds if these are the breeds one wants to conserve. That is why it is so important to **value** the breeds in the first place (as done in Chapter 5.3) and then to calculate the **costs** of conservation in a second step. Values/benefits and costs are the two major key factors that also help in understanding the **validity** of conservation, as described in the following section.

6.2.1. When is conservation worthwhile?

Pearce and Moran (1996) stated that one important rule for conserving environmental and public goods implies the comparison of benefits (BD) and costs (CD) of development (in this study that is the situation describing livestock-keepers' current management of their cattle under the assumption of utility maximisation) with the benefits (BC) and costs (CC) of conservation. Conservation is then only justified if:

$$(BC - CC) \geq (BD - CD) \tag{20}$$

This notion was modified for this study, given the nature of the underlying stated choice method. It will be assumed that the difference in benefits and costs equals the level of **utility** (U) of a breeds/subtype. This assumption translates into $(BC - CC) = U_{EB}$ (with the index EB standing for the EB subtype as the breed that should be conserved) and $(BD - CD) = U_A$ (with the index A standing for the livestock-keepers' current breed). Thus the abovementioned formula is reduced to:

$$U_{EB} \geq U_A . \tag{21}$$

For policy analysis, the researcher is often interested in measuring the COS (see Chapter 2.3.2 for more details) that is associated with a particular policy. A change in the breed/subtype can have an impact on COS that is important to assess in order to determine the appropriate subtype for conservation in light of cost-efficiency. A change in utility from livestock-keepers' current situation (i.e. from breed A that they currently stock) (U_A) to a new situation in which livestock-keepers are asked to substitute their cattle by EB and hence derive utility from keeping EB (U_{EB}) equals the COS of the EB (COS_{EB}):

$$COS_{EB} = U_{EB} - U_A \tag{22}$$

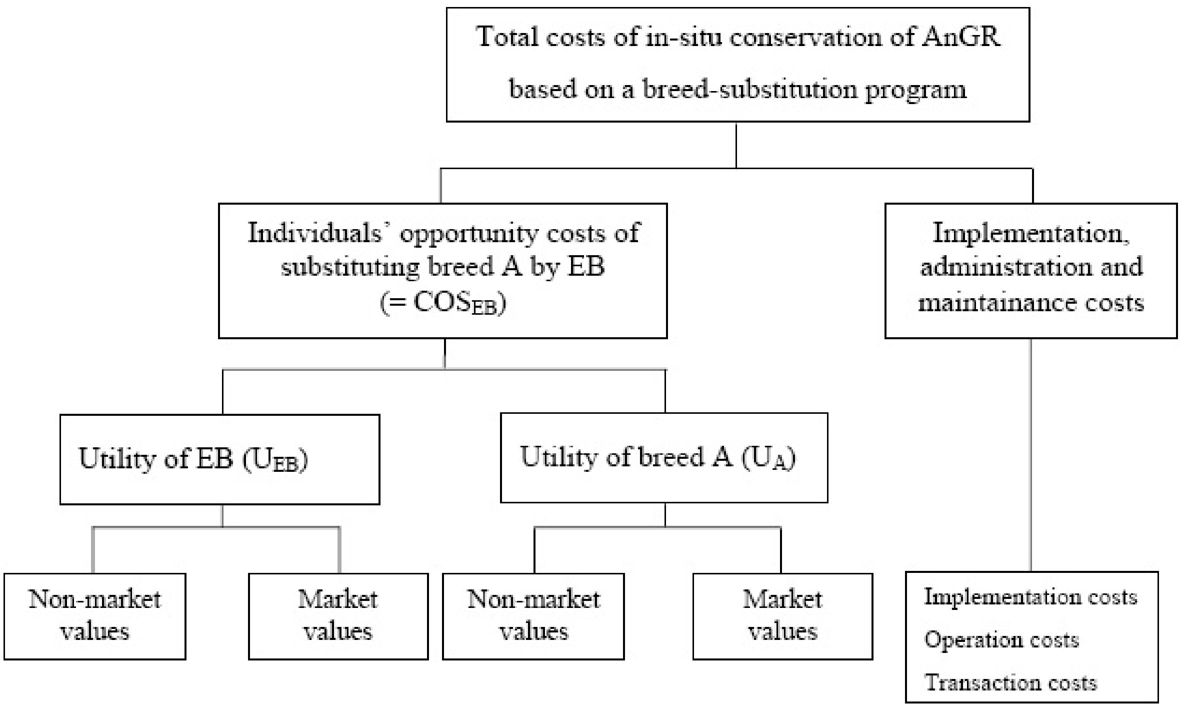
$COS_{EB} < 0$ implies that livestock-keepers would be worse-off in the new situation when substituting their breed with EB. If $COS_{EB} > 0$, livestock-keepers would derive higher utility from EB than from their current breed A and thus will not require any compensation for forgone benefits and no costs in form of compensation payments would arise.

For example, $COS_{EB} < 0$ might frequently occur because indigenous animals (like the EB) generally display a poorer performance. If a household currently keeps "exotic" or improved crossbreeds and is asked to substitute them by EB, this would most probably harm the household due to a decrease in income. This income loss in turn amounts to the OC and eventually constitutes the costs of conservation the EB (under the assumptions that all other costs are negligible small).

The aim of carrying out a CV is to assess this income loss, measured as change in utility when substituting one cattle breed by another (by the one that is desired to be conserved = the EB). The amount that respondents directly stated to be willing to accept as compensation for the **substitution of breeds** is taken as difference in breeds' utility as perceived by respondents. This discrepancy in utilities results in compensation payments and in costs of a possible conservation initiative. The concept of CVM was explained in Chapter 2.5.

This concept of breed substitution is depicted in Figure 8. Figure 8 further illustrates that the total costs of conservation equal the **OC** of conserving the breed under consideration plus some additional implementation and administration costs for operating the conservation initiative. However, costs other than the forgone income/benefits are neglected in this study. The OC further include non-market as well as market values because they are derived from a CVM where livestock-keepers directly stated the amount of compensation that they would need for substituting their current breed by the EB. For the sake of simplifying the exercise of CV, the EB was taken as the pure Borana type which is sought to be conserved.

Figure 8: Costs of substituting breeds



6.3. Gross margin analysis as a tool for assessing compensation costs

As already pointed out, costs for the conservation of the pure Borana breed are confined to costs that arise due to livestock-keeper's forgone utility (that can be, for instance, in form of forgone income due to lower production or lower adaptability or simply lower cultural value) and the possible requirement of compensation payments. Costs that are believed to play a role in *in-situ* conservation of the Borana and why they were eventually found not to be significant is briefly elaborated in this chapter 6.3.

Fixed production costs (like barns, machinery etc.) are assumed nonexistent for cattle production in the marginal areas where the research took place. However, there are a number of **variable production costs** and also some **transaction costs** for which attempts were made for them to be included into the costs analysis. The questionnaire used in this study was thus designed to grasp some information on production costs and revenues related to cattle. For eliciting variable production costs, livestock-keepers were asked about the costs for veterinarian services, feed supplementation and for herding, arising per animal per year. For assessing the revenues per year per animal, the questionnaire captured information on the amount and price of sold cattle products on the market. Cattle products that were used for self consumption were thereby not paid attention to.

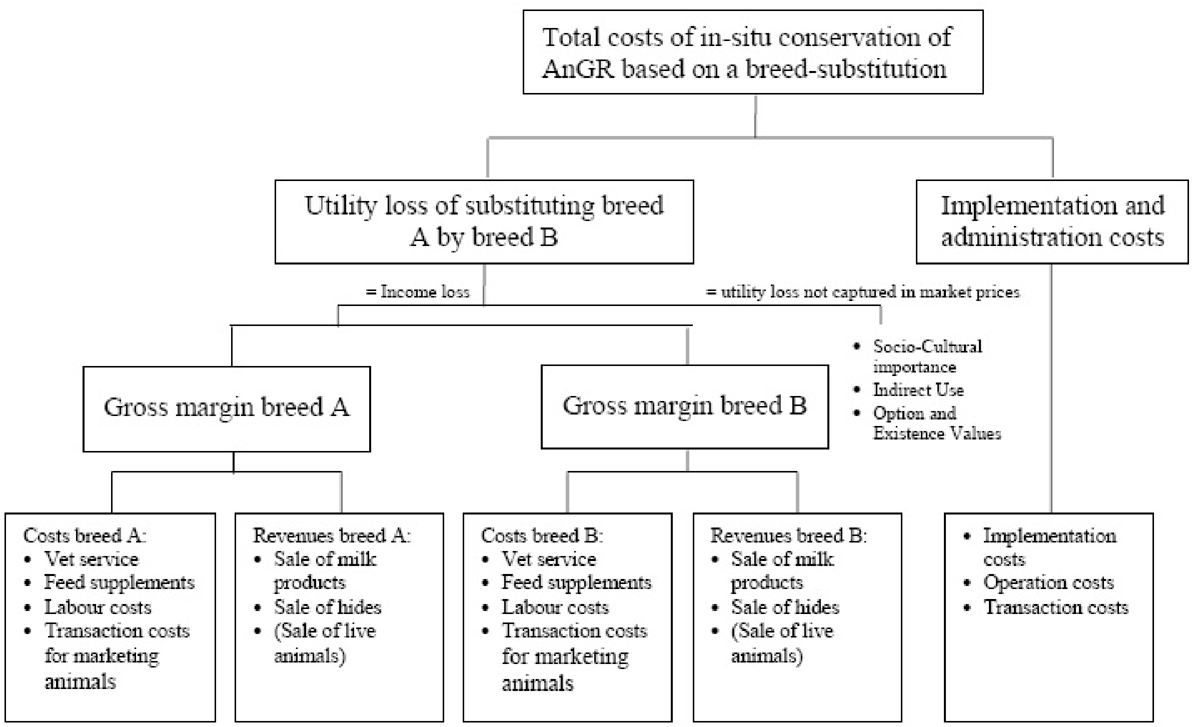
6.3.1. The concept of gross margin

Following the idea of measuring these above mentioned costs, this section briefly describes why and how the method of gross margin (GM) was initially applied to assess the costs of conserving the Borana breed. Due to the fact that quantitative cost analyses in the area of AnGRs is still very much in its infancy this approach was adopted from the field of plant genetic resources where they are widely used (e.g. see Virchow[105], 1999 or Mburu et al, 2003). However, this straightforward approach proved difficult to be carried out at the end and did not bring out reasonable results. It was hence dismissed as useful tool for assessing the costs of AnGR conservation. It is nevertheless briefly explained at this point because as "lesson

[105] Virchow (1999), for instance, defined the overall costs of the conservation of plant genetic resources (in the context of agricultural crops) as an aggregate measure of monetary costs and opportunity costs. The monetary costs represent the costs incurred from conserving plant genetic resources (e.g. for planning, planning, implementing and running ex situ and in situ conservation activities), which have to be budgeted for and then invested at a national or international level. They are determined by the specific conservation activities, the depreciation costs of investments, and the costs of institutional and political arrangements for access to plant genetic resources. Additionally, compensation and incentives given for maintaining plant genetic resources farm-level must be reflected in this estimate. Furthermore, there are OC at a national level to be taken into account, since these reflect the benefits for the country that were foregone by maintaining the diversity of genetic resources in the field.

learned" it can be stated that for the case of local cattle breeds in the Borana lowlands, gross margin cannot be sufficiently assessed as so that they can be used for drawing valid conclusions on the costs of conserving cattle breeds. This approach however might prove useful in cases of other AnGRs in other environmental settings, albeit the environmental goods in questions – plant and animals – are very different and assumptions made for plant genetic resources cannot be adopted for AnGRs. The main differences between the two goods that makes the application of GMA for AnGRs problematic is the fact that plants have a clear-cut lifespan (e.g. one harvest per year) for which the revenues and costs can be calculated. Revenues can easily be derived from the yearly yield. Low levels of disease or stress tolerance of one variety, for instance, have immediate impact on the yield. The death of an animal in a herd or the reduced adaptability of animals do not appear in the revenues for livestock-keepers. Even if the production of an animal is reduced due to e.g. sickness, this loss cannot be captured in the market because livestock-keepers do not sell all of the products that the animals produce daily but the greatest quantities are used for self-consumption.

Figure 9: Types of AnGR Conservation Programme Costs



The concept of the gross margin analysis (GMA) including different types of costs that enter the analysis is depicted in the subsequent graph (Figure 9) and its basis is similar to the concept of assessing costs by using CV (see Figure 8). A conservation programme was assumed to be grounded on the **substitution of breeds** that livestock-keepers currently keep (referred to as existing breeds) by the breed that is desired to be conserved (the pure Borana).

The costs of conserving the pure Borana are divided into two main assets: the **direct implementation costs**[106] and the **OC** for substituting one breed by the other (breed A by breed B).

Note that non-market benefits can also have an impact on the magnitude of the OC but in this kind of cost analysis they are suppressed. Non-market benefits include for example traction power, manure and socio-cultural uses, as well as finance and insurance functions. These cannot be captured by a GMA but instead require the application of a stated preference method (CE and CV). It is noteworthy that market data of livestock products cannot be related to specific breeds. Asking livestock-keepers at markets about the origin of their products (in terms of breeds) was found to be a rather daunting task because the concept of breeds is not very common among local livestock-keepers. Due to this fact, capturing breed-specific market values for the GMA is rather unfeasible and hence, separate calculations for specific breeds are problematic.

The programme implementation and administration costs are all the costs related to the management and operation of a conservation programme and include: implementation costs (i.e. all costs that occur prior to the operation of the programme, such as the genetic characterisation of animals that are candidates for participation in the conservation programme), operational costs (i.e. monitoring costs, including, for instance, labour costs for extension workers), and administrative costs (e.g. for the administration of compensation payments and the costs of institutional arrangements or contracts with livestock-keepers).

The GMs are important for comparing the productivity of the Borana breed, on one hand, and the competing breeds, on the other hand. The OC emanate from the difference in GMs of breed A (GM_A) and breed B (GM_B). The GMs for both breeds are calculated in the same manner, namely by subtracting the costs (C) of producing the cattle from the revenues/benefits (R). Production costs in this context include direct costs as well as transaction costs incurred when buying or selling the animals or simply gathering information related to cattle production. In this study, three direct costs were considered: feed supplements, veterinary services and labour costs for herdsmen, all costs calculated for a period of one year. Revenues from cattle production are derived from selling cattle products within a period of one year, such as milk, yogurt, butter and hides. Revenues from the sale of live animals were eventually not taken into account because only very few respondents stated

[106] Virchow (1999), for instance, categorized the costs for conserving plant genetic resources and in this scope defined opportunity costs on the one hand, and monetary costs on the other.

to sell cattle in the first place. It was also found to be critical to relate the revenues from selling animals to a period of one year. Selling animals is a rather arbitrary process and is usually happening only spontaneous (e.g. when money is urgently needed). The OC for substituting breed A by breed B (OC_{AB}) are therefore derived as follows:

$$OC_{AB} = GM_A - GM_B = (R_A - C_A) + (R_B - C_B) \qquad (23)$$

These OC equal the amount that is needed to compensate livestock-keepers for maintaining *in-situ* breed B instead of breed A. For instance, if the Borana breed has a lower GM than that of the SEAZ breed which it should replace as part of a conservation programme, a cost to the livestock-keeper occurs which would need to be compensated. In this case, these costs equal the OC of keeping the Borana breed instead of the SEAZ breed.

6.3.2. The results of the gross margin analysis and its limitations

First of all, the survey showed that many costs are literately non-existing under the circumstances under which cattle is reared in the research area. Throughout the Borana lowlands where the survey took place the production system in which cattle, no matter of breed, are kept is purely extensive. Large parts of the herds are sent to further grazing pastures (*foora*) herded most of the time by relatives, often young boys. Almost no monetary **production costs** occur and only then in cases when animals fall seriously sick. Due to the lack of nearby **veterinarian services**, the animals simply die and are consumed rather than money being spent for any kind of expensive veterinarian care. Only sucking cows, sick animals and bulls/oxen for ploughing remain in the nearest surroundings of the villages but, also in their cases, the production costs are neglectably low. No barns exist and calves and sick animals are sheltered in the families' houses. **Variable costs** might only occur from time to time when feed supplementations in form of salt are being fed. Other costs such as **labour costs** and **transaction costs** for marketing cattle (including tracking them to the market, time spent on the market for selling them etc.) will be assumed to be fixed at zero because there are quasi no other opportunities for hiring out labour and thus one cannot argue that the livestock-keepers (including all families members that are engaged in work related to cattle production) face any kind of OC when spending their time on the work related to cattle production. The same applies to transaction costs for marketing cattle. Quasi no other opportunities are at hand that would prompt the livestock-keepers to choose between, for instance, going to the market to sell/buy cattle and any other kind of activity that would result in any form of income. These considerations should be kept in mind when talking about transaction costs for livestock-keepers of participating in conservation programmes. Surely, the time that livestock-keepers need to spend in gathering information about possible compensation programmes and in training etc. will increase, but as long as no income-generating alternatives of how to spend the time otherwise exist, these costs would be very hard, if not impossible, to measure.

The results of the GMA are strongly related to this insufficient availability of and unfeasibility of capturing most of the costs. The results were not very meaningful because they faced five main problems:

1) there is very little variation in the production costs and the revenues. Thus, the mean profit per animal is almost similar among different breeds and OC cannot be computed or if it is possible, they are very little.
2) the costs and revenues cannot properly be assigned to one breed/Borana subtype because most livestock-keepers stated that they keep Borana without specifying the crossing etc.
3) transaction costs for market activities when buying or selling cattle and for information gathering (which would be an important factor when participating in conservation initiatives) were hard to quantify because of no data on livestock-keepers daily wage level and the fact that they do not have opportunities to spend their time gaining money rather than spend time with their cattle herds.
4) when calculating production costs, for some livestock-keepers no data was available because for some services no money changes hand (like, for instance, veterinary services carried out by a neighbour, feed supplement given for free by a local NGO etc.).
5) animals have no clear-cut lifespan and many changes in utility (as e.g. sickness) do not appear in a change in income because the majority of animal products are for self-consumption and not sold in the market.

6.4. The costs of conserving the Ethiopian Borana subtype

This section finally provides the results of the **CV** exercise upon which the costs of conserving the pure **large-framed EB** are calculated. Given the fact that a WTA approach is to be used, extra care must be taken to ensure that respondents do not overbid. Therefore, in this study an open-ended approach with following **bidding game** was applied to overcome the threat of exaggerated **WTA** amounts and to elicit realistic values from the respondents. An upper limit was set as starting point for the open-ended question, namely for the Kenyan survey 100,000 KSH[107] and in Ethiopia 10,000 Birr[108]. This measure avoids unrealistic staring

[107] Taking the exchange rate from May 2004; 1€ = 80 KSH; it amounts to 1250 €.

points, i.e. values for starting points that by far exceeds the usual income of people in the research area.

It was therefore decided that the CV design only focus on the EB because it was assumed that the EB is the pure Borana breed, expressing unique traits and unique genetic material. The EB was described by the enumerators as being the large-framed one, named EB or *Qorti*. The CV approach is contingent on a specific hypothetical scenario and description of the animals and the change in scenarios described is typically hypothetical (Bateman et al., 2003). Under this approach, the livestock-keepers were confronted with the hypothetical scenario of replacing their existing cattle. It was described that as **substitute** livestock-keepers would receive the pure Borana cattle (EB). Hypothetically, respondents had to give up their other breeds and in return obtain the same number of cattle, but solely EB. It was assumed that **no costs** would accrue to the livestock-keepers for this exchange, that the substitute would be freely **available**. The interviewees were first asked whether they would be willing to accept compensation or not. In an **open-ended question**, they then stated the annual amount of money they would need to receive for solely keeping the pure Borana cattle. Thus livestock-keepers first stated the money they would need to "tolerate" the loss[109] they might face when giving up their cattle herd in exchange for EB cattle. They were thereby offered declining levels of compensation until they refused to go any lower. The mean of the upper and the lower bounds was then used to determine the "true" level at which livestock-keepers would be WTA compensation. This amount is equivalent to the livestock-keepers' perceived forgone income as a result of maintaining only pure Borana breeds in their herds. In other words, it is the **OC** of conserving pure Borana cattle *in-situ*.

Respondents cannot give details on the exact breed they are keeping and hence they could not clearly define the breed that they would "sacrifice" in favour of keeping EB. This is, though, not a major problem because they do know the differences in utilities that they derive from their breed and that they would derive from the EB. They can hence make statements about losses or gains in utility that will occur to them with the new situation (with conserving the EB).

Respondents were allowed to opt-out when they had no opinion about WTA values. This option was granted in order to reduce the risk of **invalid zero responses**. Livestock-keepers should only respond with a zero value when they truly did not need any compensation when

[108] That is 1000 € with the exchange rate from May 2004 (1€ = 10 Birr).

[109] It was initially assumed that respondents keep their favorite cattle breeds that they have developed over decades and that they would hence face a loss when switching to EB.

substitution of their breed by EB occured. It was found to be too complex and time consuming to separately ask livestock-keepers about their WTA for all four Borana subtypes.

It has to be stressed that the CV question was designed in such a way that livestock-keepers were not able to state **negative WTA** compensation for maintaining the EB, i.e. they were not allowed to state a positive WTP even if they said to have higher utility from the new situation in which they were asked to keep the EB. This higher utility was simply limited to **zero** WTA compensation. This is the reason why on average WTA is always positive and hence result in **costs**. Taking into considerations the high net values for the EB subtype (see Chapter 5), it needs to be made clear why in this chapter costs for maintaining the EB are addressed. Without limiting the possible answer of the CV setting to either zero WTA compensation or positive values, many livestock-keepers would have stated a negative WTA, i.e. a WTP for substituting their status quo breed for the EB and consequently the average costs would have been negative.

6.4.1. Results of the CVM

The results of the CV carried out in **Ethiopia** reveal that 228 of the 246 (93 percent) livestock-keepers interviewed held an opinion regarding whether to require compensation or not. Approximately 20 percent of those 228 livestock-keepers (46 livestock-keepers) stated that they would require compensation. The amount of compensation solicited by the livestock-keepers that require compensation in the first place, ranged between €8 and €120 for each animal per year, with a mean of €36.4 (see Table 28). The remaining 80 percent of Ethiopian livestock-keepers (182 individuals) stated that they did not need any compensation at all for maintaining the EB. The mean over the whole sample (the 228 livestock-keepers with valid response) was found to be very low at €7.3 per substituted animal.

In **Kenya**, on the other hand, the demand for compensation was expressed more frequently. Out of 121 livestock-keepers, 85 indeed would require compensation (=70 percent) and hence only the remaining 30 percent (= 36 individuals) would be willing to maintain the EB at zero costs. On average, these livestock-keepers who would accept compensation require €88 per animal with a minimum of €13 and a maximum of €531 per animal. The sample mean amounted to €61.8; that was €54.5 more than the Ethiopian sample mean.

For the **pooled data** set, the sample mean equaled €26.2 per animal per year (for 349 valid responses). This amount quantified the average **OC** of exchanging a livestock-keeper's animal of his/her current breed by an animal of the EB type.

Table 28: Mean compensation costs in € per animal – by country

	Ethiopia	Kenya	Pooled
Sample mean[110]	7.3	61.8	26.2
Standard deviation	18.3	75.4	53.4
Range (min-max)	0-120	0-531	0-531
Number of individuals	228	121	349
Mean only for **those with compensation costs**	36.4	88.0	69.9
Standard deviation	3.6	76.2	67.6
Range (min-max)	8-120	13-531	8-531
Number of individuals	46	85	131

If compensation was asked for (that was true for only 20 percent of the respondents in Ethiopia, for 70 percent in Kenya, and overall for 38 percent), then the amount was split into five categories, as detailed in Table 29. The stated amount in Ethiopia was most frequently within the category of "€16 - €50" per animal per year. It is remarkable that Kenyan respondents seem to require higher compensation payments, most frequently between €51 and €100 per animal per year.

Table 29: Distribution of households according to stated level of compensation required (% of households) – by country

Categories (€ per year per animal)	Ethiopia	Kenya	Pooled
No compensation	80%	30%	62%
1-15 €	3%	2%	3%
16-50 €	14%	17%	15%
51-100 €	2%	33%	13%
More than 100 €	1%	19%	5%

6.4.2. Comparison of WTA and WTP values

The study results yield two different sets of welfare measurements: the WTP and WTA values obtained from the CE analysis and in terms of breeds *per se* from the simulation process (see Chapter 5.3) and the WTA values derived from the CV (see also Chapter 2.3.3). The results of this study led to a WTP value for conserving the EB breed (see Chapter 5.3.3, Figures 4 and

[110] The means of the WTA values for Kenyan and Ethiopian respondents were compared using SPSS 13 (Norusis, 2004) and were found to be significantly different between both data sets. As a test statistic, the t-test was applied, showing a significance value less than 0.05. It can be inferred that there is indeed a relationship between the country and the value for the mean WTA. There is also a significant correlation between the WTA value and the country dummy variable, with the chi-square test statistic revealing a significance value less that 0.05.

5) that is four times higher than the WTA value (Table 28). The WTP estimate for EB amount to €105 (average amount for bulls and cows[111]), while the estimate of the WTA compensation for conserving the EB subtype amount to only €26 per animal. The reason for this big discrepancy is, as already indicated (see Chapter 2.3.3 and Chapter 6.4), the design of the CVM that does not allow for negative WTA statements made by respondents (in contrast to the CE that allows respondents to state WTP and WTA values).

The country-specific results of the MXL model further suggest that Ethiopian livestock-keepers had a €114 higher utility from EB than Kenyan livestock-keepers (Chapter 5, Table 23). The findings of the CV validate this tendency because they expose higher costs of conserving the Borana in Kenya, compared to Ethiopia. Due to Kenyan livestock-keepers' lower utility from the EB subtype, they would ask for higher compensation payments for maintaining this subtype in their herds (€54.5 more; see Table 28). The CVM shows that in Kenya many livestock-keepers have a WTA compensation of larger than zero, with an average WTA of €61.8 (see Table 28). Given this relatively high share of respondents stating that they would obtain less utility from the EB than their status quo breed, it is expected that the CE has verified this finding. The CE (see Chapter 5.3) indeed exposes lower WTP indicators for the EB subtype from Kenyan than Ethiopian respondents.

6.4.3. Implications for managing conservation programmes

Costs are in particular relevant when looking at the **time horizon** of a conservation programme. **Implementation costs** only occur once but costs in form of possible compensation payments to livestock-keepers constitute a continuously cost asset that needed to be paid annually and per animal. Unless the perfect duration of a conservation programme is known (although many scientists suggest between 10 and 50 years), the costs remain unmanageable.

If the **markets** further develop over time and livestock-keepers get more involved into market activities (as it is the case in Kenya), they will be affected by these new opportunities to gain money with intensive cattle production. Hence the OC of maintaining the pure Borana are likely to increase for them and the benefits will decline. Established conservation programmes have to adjust for this change due to market forces. One solution would be to increase compensation payments gradually over time, taking into account relevant **discount rates**.

[111] The WTP estimate for cows equals €100, that for bulls €149. Hence, taken the average value for a herd size of nine cows and one bull the value per animal can be calculated by (9*100+1*149)/10 = 105 (see also Chapter 5.3).

A **zero-cost approach**, on the other hand is achieved when, after a certain time (say after a short implementation phase), a programme becomes **self-supporting**. That is fulfilled only when livestock-keepers do not require continuous compensation payments and the performance of a programme does not result in annual costs anymore. That can be achieved by targeting the “right” livestock-keepers for participating in conserving the EB breed.

Against this background the study emphasises four criteria that should be considered to achieve the most cost-efficient *in-situ* conservation programme. The net costs of conserving Borana cattle depend thus on:

- The breed that should be conserved (here only analysed for the EB)
- The breed that would possibly be replaced (or better the utility livestock-keepers have from the breed/crossbreed that they would replace
- The country in which the conservation programme should be set
- The production system in which the participating livestock-keepers produce

The CVM brought to light that 80 percent of livestock-keepers in Ethiopia and 31 percent of livestock-keepers in Kenya would be willing to maintain the EB in their herds at no costs. Bearing in mind the desire to conserve the pure Borana breed (EB) as cost-efficient as possible, that would mean that targeting these shares of livestock-keepers results in a quasi zero-cost conservation programme (at least no compensation payments). Some transaction costs might emerge but as pointed out, they were not seen as a viable asset with regard to this study and the livestock-keepers’ situation. What would remain in this case are only the implementation costs that some institutions/donor/government have to bear.

If it were not possible to target only these livestock-keepers that do not need any compensation for replacing their breed by EB, then it would be more cost-efficient to involve Ethiopian livestock-keepers because they stated that they would require €54.5 less compensation payments per animal per year than Kenyan people. This lower sample mean, of course, is also due to the large share of Ethiopian livestock-keepers not needing any compensation. Conservation programmes that aim at both countries should consider compensation payments of about €26 per animal per year for each household that participates with its cattle.

To determine overall costs of a programme, it would be of interest **how many animals** are required for a successful conservation programme. The level of compensation payments to livestock-keepers depend on the number of animals to be conserved. This consideration and other practical issues of *in-situ* conservation programmes are the subject of Chapter 7.

6.5. Summary

Before revealing the results of the CVM, this chapter reviewed key concepts commonly applied for the assessment of costs of environmental assets and public goods. To measure the costs of conserving the EB (in hope and assumption that this subtype is the "pure" Borana breed containing all valuable Borana unique genes and traits) it was finally opted to elicit direct WTA compensation for conserving this large-framed EB type by applying a CVM. The amount of WTA values constitute the costs of substitutability of breeds and can be interpreted as the main costs that accrue for *in-situ* conservation set up in developing countries. No other costs than these OC were regarded as meaningful to *in-situ* conservation in this harsh East African environment, not to mention that they were regarded as unfeasible to measure (like transaction costs for example). The results gave reasonable values, which were also in line with those obtained from welfare measurements from the CE. The main result of the CVM was that 62 percent of respondents would conserve the pure Borana at zero costs because they would face no loss utility but rather would be better-off (the CVM setting was constrained in such a way that livestock-keepers could only state to have a WTA of zero; no negative values for WTA compensation were allowed). If it was stated that compensation payment would be required, it were mostly Kenyan livestock-keepers who did so (70 percent) while in Ethiopia only 20 percent stated that they needed compensation for maintaining the EB. The mean WTA value over all respondents was found to be €26 per EB per year. The findings of this chapter further suggest that involving livestock-keepers in Kenya is more cost-intensive than involving Ethiopian livestock-keepers.

The assumption that *in-situ* conservation is rather inexpensive can be verified by assessing the utilities of different breeds and Borana subtypes as perceived by local livestock-keepers. Thereby, costs that would occur due to forgone benefits (OC) from conserving the EB are low compared to the potential benefits that could emerge from genetic resources (see Chapter 5). Limiting a potential conservation programme to one country can also cut down conservation costs.

Ultimately, it can be stated that the choice of an appropriate approach on how to quantify the costs of conservation of AnGRs remains difficult and is still in its infancy. One reason for this was found to be the unfeasibility of conducting a GMA for AnGRs. GMA analysis exposed promising results in the field of plant genetic resources but its application to assess conservation costs for the Borana breed in East Africa under the umbrella of a community-based conservation programme yielded no convincing results and was not recommended.

CHAPTER SEVEN

Priority ranking for conserving Borana cattle

7. Priority ranking for conserving Borana cattle

This chapter moves away from the economic perspective and analysis of cattle attributes and breeds and addresses more specifically the issue of the genetic[112] value of Borana cattle. Chapters 5 and 6 only elaborated on the value of the Borana breed and its subtypes from an **economic point** of view and more precisely based on the local livestock-keepers' utility and preferences. In order to define better "what" breed shall be conserved, this economic value is not sufficient because conservation programmes should also take into considerations **breeders' and conservationists' objectives**. They, unlike the local livestock-keepers, might want to conserve a particular Borana subtype out of other interests or might not want to conserve it at all. A breed/subtype that has **unique characteristics**, that is **genetically distinct from** other breeds/subtypes, whose **usage** is economically reasonable and makes the livestock-keepers better-off should obtain maximal conservation priority and should be conserved in the most **cost-efficient way**. This notion is reasonable but its implication is very difficult and not all of these objectives might be achievable at the same time. Hence, the broader aim of this research is not only to put "a price tag" on the Borana and other breeds and also define the costs of conservation based on a change in utility and preferences, but also to maintain "valuable" genetic material. In this regard, the main objective of this chapter is to reveal a **priority ranking** for the relevant Borana subtypes that should be considered for conservation. The ranking thereby will be based on a combination of economic and genetic values of Borana and its subtypes relative to other breeds that could alternatively be conserved. Defining priorities for conservation among the breeds and subtypes is done by applying the **Metrick-Weitzman criteria**. Furthermore, this chapter underpins livestock-keepers' **awareness** for the need for maintaining the Borana breed and of their degree of willingness to participate, and finally this chapter outlines possible **conservation programmes**[113] and which practical issues should be taken into account.

[112] In literature and throughout this work the terms "genetic", "ecological" and "biological" value are used synonymously with each other.

[113] Throughout this study the term conservation strategy determines whether AnGRs will be conserved *in-situ* or *ex-situ*. This study's objective is not to evaluate the strategy *per se* because it is assumed that *in-situ* conservation is the most appropriate way to enhance future use of genetic material but to assess the cost and feasibility of conservation programmes within this strategy.

7.1. Relevance and theory of ranking schemes

Choosing among biodiversity-preserving alternatives of AnGRs is difficult and a sound cost-effectiveness framework that helps guiding policy is still absent (Weitzman, 1993). One main issue in conservation issues concerns the determination of the “object” that should be taken in account for conservation in the first place. Many driving factors enter the decision-making process but eventually one has to decide on how to assess different factors in order to conclude in a ranking scheme determining “what” should receive the **highest priority for conservation.**

As already seen in Chapter 5, different breeds and subtypes have different utilities for local livestock-keepers and, from this economic point of view, there is already a tendency towards breeds/subtypes that deserve conservation. Assuming that the question of selecting the appropriate Borana subtype (out of the three relevant subtypes, as explained in Chapter 3.3) for conservation does only depend on these utility values seem to be inappropriate because it does not reflect the genetic value that is thereby conserved. Only selecting one breed or subtype because its conservation would bear the minimum costs and a conservation programme for it can be commenced and maintained without difficulties is an inappropriate solution even when it does not contain valuable genetic material. Therefore, important considerations are the present and future economic and genetic contexts in which the breed/subtype exists.

The conservation of AnGR is, on the other hand, not justified in the interest of the genetic resources only. In this context, one strategy would be to conserve as many genes as possible (and therefore the widest range of animals of different subtypes) (see Weitzman, 1998) in order to fulfil future needs with regard to environmental changes or other catastrophes (e.g. epidemics, droughts). Nevertheless, a limited budget does not allow for all four subtypes to be maintained. That would not only be very cost-inefficient but also infeasible because then too many areas and local livestock keepers would be involved and hence transaction and operational costs would be immense, resulting in impossible future management of the conservation programme. Further, only observing genetic factors and conserving, for instance, “what is most distinct” or “what is most endangered but not distinct from others” or more optimal “what is most endangered and most distinct” would be too unrealistic and not easily achievable given the scarce financial resources for global biodiversity conservation. Moreover, policy implications where costs do not play a role are rather inefficient. Cost-efficiency of the Borana subtypes relative to each can be assessed by applying a sensible priority ranking.

One alternative for priority finding is applying **weighting factors**, as done by Simianer et al. (2003)[114] and Reis-Marti (2004). It is worth mentioning that weighing is promising but also subject to **subjective decisions**. Quantitative methods for prioritising AnGR conservation such as **index calculation** and assigning **ranking scores** have long been hampered by lack of data (Ceballos and Navarro, 1991) but their objectivity and repeatability are higher than in qualitative methods (Todd and Burgman, 1998). Using scores as one dimension makes economic and genetic values **compatible and comparable** (Mace and Lande, 1991).

In this study it was refrained from applying index calculation due to the different dimensions of economic and genetic values of Borana subtypes which would make it difficult to describe the "true" or aggregate value of the Borana breed and its subtypes in monetary terms. The approach that was used in this study for priory setting between Borana subtypes is based on the **Weitzman criteria** that constitutes an economic method of assessing biodiversity and upon which priorities can be calculated. This approach was opted for bearing in mind that the conservation of the Borana breed aims at, firstly, the conservation of Borana genetic material that is responsible for the breed's unique characteristics, and secondly, consequently at maintaining cattle breed diversity. As a proper **unit** of priority setting for conservation, this study is limited to the unit of breeds[115] or better, further narrowed down to the unit of subtypes of the Borana breed. Weitzman uses in his crane example the unit of species but he suggests that his approach is relevant for any other units as well (Weitzman, 1993, p. 160).

The entire study has so far focused on the monetary value of Borana cattle (see Chapters 5) and on the relative costs of conserving one animal of the EB subtype (see Chapter 6). However, genetic values of Borana cattle were not captured so far by these approaches and no implications on cost-efficiency could be drawn either. That is why Weitzman's work on priority setting will be picked up as a last point of this study. That enables an almost complete

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[114] Simianer et al. (2003) further introduced the "expected overall utility" criterion as a possible solution for combining ecological and economic factors.

[115] The objectives of conserving AnGRs focus on two separate but interlinked concepts. The first is the conservation of "**genes**" and the second, the conservation of "**breeds**" or populations (FAO, 1999). The conservation of "genes" refers to action to ensure the survival of individual genetically controlled characteristics inherent within a population or group of populations. It could, for example, be trypanotolerance, polledness, wool shedding, or a specific milk protein (Henson, 1992, Chapter 3). Such programmes require that the characteristic to be conserved is clearly recognized and identified. It is safe to say that this is not the case for the Borana breed and in particular not of its subtypes and hence a conservation strategy for the Borana should aim at the conservation of the whole "breed", and to be more precise of its "subtypes".

picture of the Borana breed by providing ranking positions for the subtypes based on the **combination of genetic and economic factors** of the Borana breed and subtypes.

There seems to be a growing consensus that genetic and economic values must be combined in order to resolve into a “true” value of a breed/species and that priority setting is closely related to a sound combination of economic and genetic factors. Until now, two approaches in evaluating AnGRs were often carried out separately, resulting in studies using an approach related to the genetic values of breeds/species, and otherwise studies focusing on their economic values. Important studies on the economic evaluation of AnGRs conservation that triggered the framework of this thesis were already mentioned, including Drucker et al. (2003), Scarpa et al. (2003a; 2003b), Tisdell (2003). Weitzman’s approach is the most relevant for this study and the theory behind it will be explained in more detail in Chapter 7.1.2 while the following section gives an overview of studies that have been conducted so far on the genetic evaluation of AnGRs and which were relevant to this thesis.

7.1.1. Background on genetic assessment of AnGRs

To the same extent to which many studies only focus on the economic values of AnGRs, many other authors and their approaches only consider genetic values. There are various aspects that shed light on the genetic composition of cattle but two aspects are always pointed out explicitly: extinction probability and genetic diversity. It is worth mentioning however, that in the scope of this work it was only feasible to assess the degree of endangerment, not the genetic diversity of Borana and its subtypes.

Credit has been given to Hannotte et al (2000) for important work in the field of assessing genetic values of FAnGs. In this paper, genetic diversity is taken as key factor for assessing the “value” of cattle breeds that should deserve conservation priority based on the genetic distinctiveness. Rege et al. (2001) and Simianer et al. (2003) also recently picked up the issue of measuring genetic diversity of farm animals, conducting case studies with respect to East African cattle. In both studies, measures of heterozygosity and allelic diversity were obtained by using **microsatellite markers**[116] on **blood sample**s in order to obtain the necessary

[116] Molecular markers are a tool to study the diversity on the genetic level. The most widespread use of molecular markers in this context is the assessment of diversity within and between breeds (Simianer, 2005a). **Microsatellites** are highly informative markers for studies of genetic diversity, gene flow and phylogeny in domesticated animals. They represent the most powerful tools for evolutionary studies of nuclear genetic variation currently available (Mac Hugh, 1996). Applying the microsatellite technique has been pioneered by Bradley et al. (1996) and Mac Hugh (1996).

genotype data. Using microsatellites markers is nowadays the most powerful tool for **measuring genetic distance**s.

Many studies (see Nehring and Puppe (2001; 2002) or Simianer (2003; 2005b)) are moving away from the notion that the most endangered breed/species should be given conservation priority and rather base the conservation priority on the degree of distinctiveness (certainly not ruling out that a breed/specie can be both, endangered and distinct from others). This notion has found wide acceptance in conservation science. The introduction of sophisticated genetic analyses of farm animals and the development of appropriate molecular markers made it finally feasible to obtain necessary data for such an analysis.

7.1.2. The Weitzman approach

Pioneer work in the field of setting up priorities for diversity conservation was done by Weitzman (1992; 1993) whose approach is widely used to rational decision-making in livestock-conservation (Simianer, 2005b). Weitzman's approach, in fact, constitutes an economic framework for the measurement of the value of diversity in which distinctiveness additionally enters the utility function. This followed a practical example of the diversity and conservation of crane species (1993) and his work on Noah's Ark Problem (1998). Additionally, Metrick and Weitzman (1998) embellish the economic theorem with data.

The Weitzman's approach is based on measuring "aggregate dissimilarity" between species. These dissimilarities constitute the pair-wise distances between any pair of species that are then taken to measure diversity between two objectives (species or breeds). Weitzman (1998) further elaborated the problem of protecting biodiversity under a limited budget constraint. Therefore, he assumed that the loss of biodiversity due to the extinction of a species is exactly equivalent to the distinctiveness of that species (**Weitzman's criterion**). This means that the uniqueness of each species depends on the **genetic distance** between itself and its nearest relative.

The Weitzman criterion has since then been the topic of many subsequent studies all aiming at its improvement and refutation of its validity. The main **point of criticism** was that Weitzman's criterion only holds under the very strict condition of the absence of ecological relationships among species. Owing to this fact his criterion does not seem to be suitable for providing general information about which species to protect through which protection

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Simianer et al. (2003) who first of all also slightly modified Weitzman's concept but later on (2005b) argued that Weitzman's approach is not useful with respect to livestock because livestock breeds within species lack homogeneity and clear distinctiveness, two diversity elements upon which Weitzman's criterion is founded..

projects (van der Heide et al., 2005, p. 221). The authors concluded that for *in-situ* conservation, Weitzman's criterion is only suitable if ecological relationships are of little importance. Nevertheless, for this study, where distinctiveness was not quantified at all and genetic values overall played a minor role compared to economic utility and costs, his criterion seems to be an appropriate approach.

The question that Weitzman (1998) and Metrick and Weitzman (1998) attempted to solve was "which species to take on board **Noah's Ark**. In literature it is nowadays known as **Noah's Ark Problem**. The suggestion was that Noah should take species on board "in the order of their gains in utility plus diversity, weighted by the increase in their probability of survival, per dollar of cost" (Metrick and Weitzman, 1998, p. 26). The authors thereby suggested the following concept, built around **four major aspects**, upon which the calculation of the ranking value R_i is based.

$$R_i = [D_i + U_i]\left(\frac{\Delta P_i}{C_i}\right) \tag{24}$$

where:

R_i = ranking value

D_i = distinctiveness of i = how unique or different is i

U_i = direct utility of i = how much a person like or value i *per se*

ΔP_i = change in survival probability = by how much can the survivability of i actually be improved

C_i = how much does it cost to improve the survivability of i by ΔP_i

Weitzman (1998) described R_i as "expected marginal distinctiveness plus utility per dollar" while van der Heide et al. (2005) used the term "performance index" for R_i. In this study R_i will be simple referred to as ranking value of Borana subtype i. ΔP_i will be used differently from Weitzman's notion as well. Instead of a change in the survival probability that can be archived by a conservation programme, the **extinction probability** (z) will be calculated for the purpose of this study. z is 1 minus the survival probability (Weitzman, 1993; Pearce, 2001) and here it is calculated for the **present situation** of a breed, not taking into account a possible change induced by a conservation programme (see Chapter 7.3.1).

The two authors (Metrick and Weitzman, 1998, p. 26) also noted that it will not be easy in practice to quantify the four variables nor will it be easy to combine these variables routinely into a simple ranking formula. Nevertheless, this last chapter of this study attempts to give an answer on the practicability of the Metrick-Weitzman criteria.

7.2. Livestock-keepers perceptions about the Borana breed

Prior to the results of the ranking, this section gives an overview of livestock-keepers' perception on the Borana breed and breeding objectives that have influence on the survival of certain subtypes. Livestock-keepers were directly asked about their opinions and their answers are important to understand the degree of endangerment of different subtypes and hence their extinction probability. As will be elaborated in Chapter 7.3.1, the estimation of extinction probabilities (z_i), entering the calculation of ranking positions as one important aspect, heavily rely on expert opinion and also on the livestock-keepers' perceptions. Livestock-keepers' opinions are thereby only taken as additional information but they constitute an appropriate proxy because livestock-keepers, as they have witnessed how the breeds, the environment and the production system have changed over time, seem to best appraise the situation.

Table 30: Livestock-keepers attitudes and perceptions towards cattle breeds (all in %)

1. Awareness of change in cattle herd composition			**2. The land where cattle can graze became less**		
	Ethiopia	***Kenya***		***Ethiopia***	***Kenya***
Very aware	41	58	Very aware	80	66
Aware	25	14	Aware	7	3
Not aware	31	23	Not aware	11	24
No opinion	3	5	No opinion	2	7
3. It became harder to find pure Borana on local markets			**4. Keeping crossbreeds in the herd is very important**		
Strongly agree	6	6	Strongly agree	39	24
Agree	28	15	Agree	34	42
Disagree	65	79	Disagree	23	30
No opinion	1	0	No opinion	4	44
5. Introducing exotic cattle into the herd bears great benefit			**6. Keeping exotic breeds in the herd is very important**		
Strongly agree	17	**44**	Strongly agree	16	**41**
Agree	13	25	Agree	17	26
Disagree	30	15	Disagree	30	25
No opinion	**40**	16	No opinion	37	8
7. Keeping Borana in the herd is very important			**8. It is important to cross Borana with exotic breeds**		
Strongly agree	67	51	Strongly agree	15	36
Agree	28	43	Agree	20	38
Disagree	4	5	Disagree	18	7
No opinion	1	1	No opinion	47	19
9. The pure Borana is facing the risk of becoming extinct					
Strongly agree	6	2			
Agree	22	10			
Disagree	65	83			
No opinion	7	45			

Table 30 shows the results of nine questions presented to livestock-keepers in form of Likert scales, whereby the outcome of question four to nine were only used for the calculation of the extinction probability.

As already mentioned, one reason for dwindling global AnGRs is the trend towards increased intensification and industrialisation of production systems based on uniform genetic resources. In order to meet the growing demand for animal products high yielding "exotic"[117] breeds are increasingly imported and are interbred with local breeds, replacing the local breeds in some regions. This is not the case in the Ethiopian Borana zone where the replacement of the Borana is more due to other local breeds or other species such as goats and camels. Livestock-keepers were asked several questions about their attitude towards keeping exotic breeds, crossbreeding of exotic with Borana breeds, crossbreeding of local cattle with Borana and about their awareness of a decrease in Borana cattle and pasture.

It came to light, that to 73 percent (39 percent strongly agreed; 34 percent agreed) of all interviewed livestock-keepers in Ethiopia view **crossbreeding among local breeds** (including the Borana) as very important. In Kenya, the share of livestock-keepers who either strongly agreed or just agreed amounted to 66 percent and, hence, slightly less than in the case of Ethiopian respondents. This implies that the aim of the majority of the livestock-keepers is to maintain local cattle breeds but not necessarily the Borana. Livestock-keepers perceive the co-existence of the Borana cattle with other local breeds as important, a factor that reduces the likely success of conservation efforts due to the increased likelihood of crossbreeding. Thus the question arises as to whether it is possible to specifically target Borana cattle for *in-situ* conservation and how to "persuade" livestock-keepers to keep away from crossbreeding.

In contrast, keeping **"pure" exotic** breeds in the herd is very important to only 16 percent of the Ethiopian livestock-keepers but to 41 percent of Kenyan livestock-keepers. This country-specific difference in the perception of possible benefits from exotic breed can have a large impact on conservation programmes. Targeting Kenyan livestock-keepers might be less successful because with increasing time they might prefer more and more exotic breeds. Further, as soon as market access and linkages improve, Kenyan livestock-keepers that will have been initially selected as participating households might want to back off from any ongoing conservation programmes. In the worst case scenario, exotic genetic material will be

[117] Exotic breeds are high potential breeds that are imported from other countries, not only from neighbouring countries but also from North America or Europe.

brought to animals in the conservation program leading to a depletion of Borana genetic pureness again.

A similar answer was detected for the question on livestock-keepers' opinion on the benefit of **crossing Borana with "exotic" genetic material.** Again, in Ethiopia, respondents clearly do not expose "enthusiasm" about exotic genetic material for crossbreeding (only 17 percent strongly agreed that exotic genes are beneficial). The majority of Ethiopian livestock-keepers did not express any opinion at all (40 percent), highlighting the unimportance of exotic breeds and the hitherto non-existence on the Ethiopian Borana plateau. Most of the respondents truly stated that they do not have an opinion because they have no experience in this matter and have yet not seen exotic breeds or their crosses (own findings). Thus, the conservation of Borana cattle in Ethiopia is favoured by the negative attitude livestock-keepers have towards the keeping of exotic breeds and their crosses. In Kenya, to the contrary, 44 percent of interviewees strongly agreed and 25 percent agreed.

The analysis further showed that the increasing **risk status** of the Borana cattle is clearly perceived by the local livestock-keepers. For 28 percent (6 percent strongly agreed, 22 percent agreed) of the interviewees in Ethiopia it is evident that the Borana breed is facing a decrease[118] and 34 percent of them agreed to some extent that it was becoming increasingly harder to find pure Borana cattle on the local markets. In Kenya, only 12 percent of livestock-keepers were very aware or at least aware of dwindling numbers of Borana cattle. The majority of respondents in Kenya (45 percent) were not able to answer this question, and that was not a sign of strong awareness but nevertheless these figures are an indication that there is indeed some awareness and concern among the livestock-keepers regarding the current status of the Borana cattle, and upon which conservation efforts can be built. They particularly expressed fear of a gradual extinction of the larger-sized *Qorti* type of Borana cattle.

In addition, what is very promising for the success of conservation programmes is the fact that a very large share of livestock-keepers (96 percent of the households in Ethiopia and 94 percent in Kenya) viewed keeping at least one pure Borana animal in the herd as vital. This would imply that the breed has not yet ceased to be important to the Borana livestock-keepers, though it is under continued threat of genetic erosion.

In Kenya, the problem of diminishing rangeland appears to be not as urgent as in Ethiopia. In Kenya, only 66 percent of respondents stated that they were aware of this problem. These

[118] A study conducted by Homann et al. (2003b) justified these results as it revealed that the Borana pastoralists feared that the *Qorti* was in danger of gradually disappearing from the Borana rangelands.

attitudes only underpin the already mentioned severe threats to the Borana breed (see Chapter 3). They will be, however, of no further use to the calculation of the extinction probability.

In summary, the differences in perceptions of Kenyan and Ethiopian livestock-keepers can be narrowed down to three key factors that will be further taken into account in Chapter 7.3.1.

- Importance of crossbreeding with local breeds is higher in Ethiopia than in Kenya
- Importance of crossbreeding with exotic breeds and keeping exotic breeds *per se* is higher in Kenya than in Ethiopia
- Awareness of risk and perishing from local markets is higher in Ethiopia than in Kenya

7.3. Application of the Weitzman theorem and its results

Metrick and Weitzman only provided a framework and organised a way of conceptualizing biodiversity preservation. The "ingredients" for filling in into the Weitzman theorem are taken from preceding results of this study.

7.3.1. The extinction probability (z_i)

While Weitzman is referring to a change in the survival probability (ΔP_i) that can be improved by a conservation programme, for this study, the extinction probability (z_i) *per se* will be simply calculated for every Borana subtype as a proxy for Weitzman's ΔP_i. The higher z, the higher will be the ranking position for a subtype, i.e. the more "valuable it will be to conserve it.

According to Weitzman, the probability of extinction (and hence the probability of survival as well) is defined as the probability that a given breed/subtype will become effectively extinct at some time over the next 50 years. This time horizon has been adapted from Weitzman (1993). In Weitzman's crane example the extinction probabilities are just "best guesses" (Weitzman, 1993, p. 161), but not completely arbitrary. They are subjected to certain factors such as current population size and likely future trends and also, some experts' were consulted to top off the guess about the extinction probability of the different crane species.

Looking beyond Weitzman's considerations, Pearce also underpinned the importance of survival probability (the survival probability equals 1 minus the extinction probability). According to Pearce (2001, p. 31), the need for a valuation of an entire species (or here breed) is unlikely to be commonplace and most times policy makers are concerned about changing the probability of species (breed) survival. Due to the fact that this research deals with one single breed and the competing conservation priority within this breed, applying the classification systems based on categories developed by FAO/UNEP (see Chapter 2.1.1) would be inadequate.

Table 31: Variables for the calculation of extinction probabilities

Variable	Values
1) Trend over the last 10 years (TR)	0.0 = increasing 0.05 = stable 0.1 = decreasing
2) Distribution of breed (DI)	0.0 = widespread over many countries 0.05 = spread over East Africa 0.1 = localised only in the Borana lowlands
3) Livestock-keepers' attitude towards crossbreeding (=Degree of indiscriminate crossing (DC)) (derived from livestock-keepers' perceptions; see Chapter 7.2)	0.0 = negative 0.05 = positive for crossbreeding with local breeds 0.1 = positive for crossbreeding with exotic and local breeds
4) Degree of risk of replacement by other species (DS)	0.0 = none 0.05 = slight 0.1 = high
5) Organisation of farmers (e.g. herdbook, farmer associations) (OR)	0.0 = yes 0.05 = partial 0.1 = no
6) Existing conservation initiatives (CO)	0.0 = yes 0.05 = partial 0.1 = no
7) Market availability (MA)	0.0 = high 0.05 = medium 0.1 = low
8) Awareness of risk of Borana breed (AR) (derived from livestock-keepers' perceptions, see Chapter 7.2)	0.0 = existing 0.05 = fairly existing 0.1 = non-existing

Therefore, a new scheme was developed with which z can be assessed for every Borana subtype and also for the other prevailing admixtures and local breeds in the research area. This scheme facilitates making predictions about the survival of a breed/subtype. The method is largely gleaned on a work by Reist-Marti (2004). Unlike Weitzman's crane study, here the current population size does not play a vigorous role because, from the numbers aspect, there are plenty of so-called Borana animals. As already mentioned, the numbers are not the key driving factor for genetic erosions (at least not in no drought seasons) but the dilution of genes due to extensive crossbreeding are. It is rather the trend that matters. Hence, other proxies must be defined to enter the assessment of ΔP_i. z is computed as the **sum of the scores** of **eight variables** describing each subtype/breed. The eight variables were selected and for each subtype the value was defined according to expert interviews, interviews with local livestock-keepers and literature. The variables that are used here are specified for this study and when calculating the extinction probability of other species and breeds, the choice of the factors has to be reviewed. Further, the factors were chosen in such a way that they are not yet expressed by livestock-keepers' utility[119]. The relevant eight factors are listed in Table 31.

The range of the values is the same for all variables and hence every variable has the same weighting factor. The calculation of z_i was done by applying the below indicated formula and the results are exposed in Table 32. The rescaling to a value between 0.1 and 0.9 was done to rule out the possibilities that a breed may be considered completely safe from (= 0) or entirely doomed to extinction (= 1) (see Reist-Marti, 2004).

$$z_i = \sum_{n=1}^{8} z_{in} + 0.1 \tag{25}$$

The definition of values of the eight variables was based on own findings (in-depth interviews and focus groups). Missing information was obtained from the DAD-IS (FAO, 2005) and DAGRIS (ILRI, 2006a) databases. For comparison purpose only, z_i is also calculated for the local breed that was largely distributed in the Ethiopian research area, the Guji breed and the SEAZ that were the dominant local breed in Kenyan beside the Borana. It can be seen that, in particular, the Guji breed has a quite high extinction probability, in fact the second largest after the EB. This fact shows that possible conservation schemes for the Borana must take care not to completely suppress other breeds even if they are of low utility to livestock-keepers. Chapter 5 revealed that the local crosses (the Guji is similar to them) are of low economic value but this high extinction probability shows that is has high biological value. The local Kenyan breed possess a relatively low extinction probability but, as long as these two local breeds are not sought to be the target of conservation programmes, their probability will not further be used in this analysis.

[119] Reist-Marti (2004), for instance, included a proxy for unique traits. This proxy was not considered in this study because it is assumed that unique traits are already reflected in livestock-keepers' utility that they assign to one subtype. Cultural values are also assumed to be included in the utility and are not given special attention in the calculation of z .

Table 32: Extinction probabilities of cattle in the research area

Parameter	EB	KB	OB	SB	Guji	SEAZ
TR	0.1	0.0*	0.05	0.1	0.05	0.05
DI	0.1	0.0	0.1	0.05	0.1	0.05
DC	0.05	0.1	0.05	0.05	0.05	0.1
DS	0.1	0.0	0.1	0.05	0.05	0.05
OR	0.1	0.0	0.1	0.05	0.0	0.0
CO	0.05	0.05	0.1	0.1	0.1	0.1
MA	0.1	0.0	0.1	0.1	0.0	0.0
AR	0.05	0.1	0.05	0.1	0.05	0.05
∑	0.65	0.25	0.65	0.60	0.40	0.40
Z	**0.75**	**0.35**	**0.75**	**0.70**	**0.50**	**0.50**

*source: DAD-IS (FAO, 2005); **source: DAGRIS (ILRI, 2006a); all other values are based on own findings

7.3.2. Utility (U_i) and costs (C_i)

Nowadays, one of the most relevant concepts is the concept of OC of a project extending an enhanced measure of protection to a particular species/breed. If the expected gains are divided by the costs, then Noah will have expected gains per money unit expended (Metrick and Weitzman, 1998, p. 25).

Utility values (U_i) are taken from conducting a CE, as is the subject of Chapter 5 (see Table 17 and 19 in Chapter 5). Utility values are provided for each Borana subtypes, for both research countries and for both production systems. The cost estimates (C_i) are taken from the results of a CV, described in Chapter 6 (see Table 28 and 30 in Chapter 6). Costs estimates are provided only for the EB subtype, representative for all Borana cattle that should be conserved. The expected gain for each € spent for each Borana subtype is as follows:

- EB:249€/26.2€ = 9.5
- OB: 204€/26.2€ = 7.8
- SB: 248€/26.2€ = 9.5

Due to the similar utility and the fixed costs of €26.20, the expected gain for EB and SB is the same.

7.3.3. Distinctiveness (D_i)

In the crane example, Weitzman put a lot of emphasis on the genetic distances, stating that the diversity between species is the most decisive factor for priory ranking. The author defines diversity as a measure of distinctiveness or dissimilarity (Weitzman, 1993, p. 159). Normally, the Borana subtype that is most distinct should receive a high ranking position, but unfortunately, due to the lack of molecular analysis of the Borana breed in the research area, the genetic uniqueness is not known (only the unique values of the traits to local livestock-keepers; see Chapter 5). In this work, no analysis was conducted on this matter and no secondary data were available. Hence, the values for the genetic distinctiveness D_i are all assumed to be equal between the subtypes and all **set to zero.**

It is of interest, that Simianer et al. (2003) firstly slightly modified Weitzman's concept but later on (2005b) argued that Weitzman' approach is not useful with respect to livestock because livestock breeds within species lack homogeneity and clear distinctiveness, two diversity elements upon which Weitzman's criterion is founded. Due to the fact that in this study, the distinctiveness between the Borana subtypes is not known anyway, Weitzman's approach still seems to be an appropriate tool for the purpose of this work.

7.3.4. The ranking priority (R_i)

Speaking in Weitzman's language, Noah would be urged to first board the EB (R_{EB}=7.1), then the SB (R_{SB}=6.6) and, if he still had not run out of space on the ark, the OB (R_{OB}=5.8). It is noteworthy that the ranking order is different between the two research countries. In Ethiopia the OB was put into the archives in the second ranking position (37.3), after the EB (38.6) and before the SB (29.4) while in Kenya, EB is ranked first (3.2), SB second (3.1) and OB third (2.5). The highest score was detected for the EB that is stewarded in Ethiopia (38.6). This circumstance would provide a cost-efficient conservation.

Table 33: Results of the Weitzman approach for the three major Borana subtypes

Subtype	U_i	C_i	D_i	z_i	R_i
OB	204	26.2	0	0.75	5.8
EB	249	26.2	0	0.75	7.1
SB	248	26.2	0	0.70	6.6
OB_K	204	61.8	0	0.75	2.5
EB_K	262	61.8	0	0.75	3.2
SB_K	272	61.8	0	0.70	3.1
OB_E	363	7.3	0	0.75	37.3
EB_E	376	7.3	0	0.75	**38.6**
SB_E	307	7.3	0	0.70	29.4

The R_i values were not calculated for KB and for the two dominant local breeds SEAZ and Guji because they were not in the focus of entering a conservation programme anyway. The

space on the Ark is also a matter of the number of cattle Noah wishes to take on board. Applying a **safe minimum standard** (SMS) facilitates this decision.

7.3.4.1. The safe minimum standard

After having defined which animals should be taken board Noah's Ark the next step involves finding how much space is needed on board, i.e. what capacity should Noah bear in mind when building the boat? Noah needs to know how many animals he needs for a successful start of a breeding programme from scratch. For this decision-making the SMS of conservation becomes handy. In the context of this study, the SMS is defined as the minimum amount of animals of one Borana subtype that are needed for a conservation programme to make it feasible to rebuild the stock in the future (see Ready and Bishop, 1991; Drucker, 2006), i.e. a population size of a Borana subtype sufficient to ensure survival, involving the setting of quantitative and qualitative minimum limits for biodiversity preservation (see Crowards, 1998; UNEP, 1995). Further, the SMS constitutes a means to explicitly incorporating uncertainty and irreversibility into conservation project appraisal (Bishop, 1978; Crowards, 1998; Drucker, 2006). SMS approaches have widely been used in wildlife conservation, but only recently have case studies emerged for farm AnGR conservation (for example, see Drucker, 2006).

According to the FAO (1998, pp. 32) classification, a breed is "not at risk" when the total number of breeding females and males are estimated to be greater than **1000** and **20**, respectively. These numbers are regarded as a sufficient SMS indicator (see also Drucker, 2006). The number of existing Borana cattle is estimated to be greater than 1000 cows and 20 bulls (Rege, 1999a), Despite this perceived "not at risk" status, the existence of pure Borana (the large-framed *Qorti* type, that is the EB or the SB) cattle is nevertheless threatened due to manifold factors (see Chapter 3.3.4), given that the majority of existing Borana cattle are nowadays admixtures.

The results of focus groups revealed that the preferred sex ratio for the herd composition lies between 10 cows to 2-3 bulls (as stated by Ethiopian livestock-keepers) and 11 cows to four bulls (as stated by Kenyan livestock-keepers). This was equivalent to one bull for three cows. Regarding the pooled data set, on average, households kept three male cattle and 11 cows, i.e. the sex ratio equals one to four. In any case, for an average-sized herd of 10 cows livestock-keepers tended to keep only **one breeding bull**. The other bulls were castrated and solely used for traction power (own findings). For a conservation programme it is more important to look at the ratio of breeding bulls to cows and, for simplicity, it will be assumed that one household can handle **ten cows and one breeding bull.** This amount seems to be feasible for a sound management for each household. In order to conserve at least 1000 cows, **100 households** should be involved in a programme. To ensure equity and equal distribution of breeding bulls, each household should be given one breeding bull for conservation and reproduction of the pure Borana genetic material. These 100 bulls far exceed the 20 breeding bulls suggested by the SMS, and based on the FAO fulfil the "not at risk" criteria. Many interviews brought to light that keeping one breeding bull in a herd has, as a sign of wealth, cultural significance. Breeding bulls and bulls for traction are treated and perceived differently. While livestock-keepers are willing to borrow and lend bulls for traction, they prefer keeping their own breeding bull(s). Therefore, a conservation programme has to focus on the maintenance of the pure Borana, ensuring that **1000 pure cows and 100 pure bulls** will be preserved for successful rebuilding of the population at a future date, if so desired.

7.3.5. Implications from the Weitzman approach

The Weitzman ranking scores provide a first idea of the degree of conservation priority for each Borana subtype. Following the results of the ranking positions, it is recommended to conserve the EB in Ethiopia (see Table 33). Conserving the EB in Ethiopia is cost-efficient in relation to the other subtypes. As per definition, this cost-efficiency relates to a conservation programme in which per unit cost, the most valuable subtype can be conserved. The value of a subtype is further defined by its expected economic gains and the extinction probability (its genetic value).

The following three goals should be pursued for a successful conservation programme:

1) Maintaining the subtype that is most likely to become extinct (conservationist's point of view)
2) Maintaining the subtype that maximises the utility for those who keep it *in-situ* (economist's point of view)
3) Maintaining the subtype for which the costs are minimised (economist's point of view)

The quotient of (2) and (3) provides the expected gain for each € spent. As shown in Chapter 7.3.2, this expected gain is highest for the EB and SB alike. From a strict economic point of view, one could hence argue that both subtypes should be given priority for conservation. The calculation of the extinction probability, though, revealed that the EB is more likely to become extinct in a certain time horizon and hence from a conservationist's point of view it is best to maintain the EB (as also induced by the highest Weitzman ranking score). However, this section of Chapter 7 gives some examples of **hypothetical settings** from different points of view, and fulfilling different goals. It will be described why settings other than "conserving the EB in Ethiopia" should be taken into account as well. All settings exclusively apply to *in-situ* conservation embedded into livestock-keeper's participation. Furthermore, this section induces some discussion points, practical considerations and implications for the conservation of Borana cattle, deduced from the Weitzman approach.

Setting 1: Conserving EB in Ethiopia

As already mentioned, the ranking score for the conservation of EB in Ethiopia amounted to 38.6 (see Table 33) and hence fills the first position.

In order to **minimise costs**, the results of the CV can be taken as decision-driver. The results of the **CV** brought to light that in **Ethiopia 80 percent** of livestock-keepers would conserve the large-framed EB without receiving any compensation. This approach would enlist no OC but the initial implementation costs, and possible following monitoring and maintenance costs. This option certainly constitutes the cheapest setting but, however, when it cannot be ensured to target only households out of these 80 percent, not asking for compensation payments, there will be some costs for conserving the EB in Ethiopia. When EB animals are distributed for free (e.g. from a NGO) to a large amount of households, it might be that livestock-keepers requiring and those not requiring compensation payments will be involved. The average OC for Ethiopian livestock-keepers for maintaining the EB is €7.3 per animal (see Table 28). The expected economic gain per € expended amounts to 51.5 (€376/€7.2).

The total costs for conserving 1100 EB animals in Ethiopia (if the 80 percent of livestock-keepers that do ask for compensation cannot be targeted) amount to €8,030 per year. Each of the participating household would receive approximately €80 per annum as compensation payment (and incentive) for maintaining solely 11 EB animals

Setting 2: Conserving EB in Kenya and Ethiopia

Under the considerations that in Kenya and in Ethiopia a Borana subtype should be conserved, the EB possesses the highest ranking score relative to SB and OB (R=7.1, see Table 33). The decision for conserving a subtype in both countries emerges due to equity reasons and also because spreading conservation programmes over different regions also spreads the risk of being affected by diseases, droughts etc.

In Kenya only 30 percent of livestock-keepers stated that they do not need any compensation and thus when selecting livestock-keepers that want to participate in conservation programmes, it is likely that payments have to be made in order to substitute their breeds by EB. As elicited in Chapter 6 (Table 28), the average costs in both countries per animal per year amounts to €26.2. The total costs for maintaining 1100 EB animals in both countries would be €28,820 per year in form of compensation payments, i.e., €288 would be allocated per annum to each participating household.

Setting 3: Conserving EB and OB in Ethiopia

Even though the ranking scores give a concrete order for conservation priority, it might be reasonable to conserve more than one subtype. A crucial question arises towards the conservation of only **a distinct single subtype** of Borana or conserving a whole **gene pool** of Borana, i.e. targeting all three subtypes with the goal of conserving as many genes as possible as best insurance for future use. The advantage of conserving a single subtype is that it has a defined set of characteristics and parameters. Its appearance, production, and its utility to local livestock-keepers are all known. Population from such a subtype could be screened for undocumented characteristics in the future and desirable genes can be accessed through conventional breeding techniques or genetic engineering. The disadvantage of conserving subtypes separately is that one does not know which genes one subtypes contains because they are distinguished based on phenotypic characteristics and hence it is not entirely ensured that the "initial" Borana genes will be preserved. Molecular genetic analysis of all subtypes can solve this problem, though, and enables the finding of the "right" founder stock for an *in-situ* conservation programme.

The conservation of genetic variation in a gene pool or breed composite has the advantage that all Borana genes are maintained, and that is the best insurance for future use. There are two ways of conserving more than one subtype, either by conserving them separately or to combine them into a gene pool of a size considerably smaller than that required for separate programmes. There are, however, a number of serious disadvantages with gene pool conservation. The major one is that nobody knows whether the genes of the pure Borana are sufficiently preserved in a gene pool. The separate subtypes of Borana are well described in their appearances and production performances, while a gene pool or composite population is not predictable in the expression of those characteristics. Secondly, the identification of subtypes carrying a specific gene within a composite may be impossible to determine because expression of the gene may become masked by alternative alleles found in the other subtypes in the composite. Preserving 1100 animals of a pool of EB and SB and OB bears the risk that one of the three subtypes will be underrepresented. In the light of these serious disadvantages, it is recommended to conserve the Borana subtypes **separately**.

From the viewpoint of a high extinction probability it is recommended to allocate the highest conservation priority to the EB and to the OB alike (see Table 32). From an economic point of view, the EB and the OB perform best and second best in **Ethiopia**, while in Kenya, the OB performs worse in terms of utility to local livestock-keepers. Hence, if it is desired from conservationists to conserve the two subtypes EB and OB it should be done in Ethiopia[120] rather than in Kenya. The total net costs for this setting would rise to 2200 times €7.3: €16,060 per annum. The costs per animal are the same as for setting 1. This is due to the fact that the costs were only calculated for the EB and assumed to be the same for EB, SB and OB. The expected gain per unit cost, though, is less than for the conservation of only the EB in Ethiopia, namely 50.6 (369.5/7.3)[121].

The costs of the conservation of 1100 EB and 1100 OB are of course quite high but this setting is recommended from a strict conservationist's point of view because these two subtypes are equally endangered (with the same extinction probabilities).

7.4. Community-based conservation programmes

Conservation programmes aiming at less favoured households constitute an important source of additional income to those households that often also produce at a very small-scale level mainly for self-consumption. 80 per cent of livestock products originate from households keeping 3 to 5 animals on less than 2 ha of land (Rangnekar, 2001). Those figures show that it is inevitable that **small-scale** livestock-keepers are included in conservation programmes and community-based and "**pro-poor**" approaches are developed. AnGRs conservation from a livelihoods perspective is not only best suited to improving the livelihoods of the poor but also to ensuring **equitable access** to these resources (Anderson, 2003). This section will give an overview of benefits generated by a community-based strategy as well as of some discussion points for final implementation of such a strategy.

7.4.1. Benefits and opportunities

Creating **alternative opportunities** for livestock-keepers to increase their income from pure Borana production would be beneficial for conservation efforts as well because eventually livestock-keepers would generate such a high income on the market that previous forgone benefits (if they existed in the first place) could be equalised. **Higher market prices** for meat

[120] The ranking score for conserving EB in Ethiopia equals 38.6, the one for OB in Ethiopia 37.3; the two highest values (see Table 35).

[121] The average utility from the EB and OB subtypes in Ethiopia was simply obtained by calculating the mean utility ((376+363)/2=369.5) (see Table 23).

and milk products that stem from pure Borana would be one way to compensate livestock-keepers through market forces. In particular in Kenya, where market linkages are improving and many cattle products and live animals are sold to the Nairobi market, it is reasonable to introduce **certified** meat and dairy products. This high quality meat (for which the Borana breed is well known) could come from Borana bulls that were born within the breeding scheme of the conservation programme (and then sold to local livestock-keepers for fattening[122]). The certification of the meat would make sure that the animal was Borana. Selling pure Borana bulls out of the conservation programme is practicable because only a few (possibly the best) bulls would need to remain in the programme for further mating. Achieving higher market prices due to high quality products derived from the pure Borana eventually takes conservation programmes towards **self-sustainability** (=zero costs) because livestock-keepers would not face any forgone benefits anymore.

In the best case, **incentives payments** are required for a short time in order to bridge the initial gap of utility to local livestock-keepers between the breed that need conservation and the commonly commercial breed. This is only applicable when livestock-keepers who usually keep commercial breeds with higher utility would be target and thus OC would occur for which they have to be **compensated** for. The question of self- sustainability also answered the question of the **time horizon** of conservation programmes. If no self-sustainability, at which the level of costs amounts to zero, can be reached, the duration of a conservation programme might be **infinite** and precise costs calculations are impossible. On the other hand, a conservation programme can be stopped when livestock-keepers derive such a high benefit from the pure Borana breed that they will keep it in the long-run, making sure that there will be no shortage in restocking of pure animals (see also Chapter 6.4.5).

The possible finite duration of financing an *in-situ* conservation programme constitutes an important advantage over cryoconservation because there, maintenance costs are **permanent**.

7.4.2. Discussions and practical considerations

There are still so many decisions and arguments that have to be accounted for when a conservation programme should eventually be launched. Practical issues then need to be considered, and a few of them are outlined in this section. Elaborating these points would be, however, beyond the scope of this study.

[122] In a breeding scheme aiming to increase the population site of the pure Borana, female animals are more important for fast reproduction and only a few bull calves are usually kept for later replacement of breeding bulls. Livestock-keepers can chose what to do with the "spare" bull calves and they can be used for meat production as well. Section 7.3.3 in this Chapter will further elaborate on this option.

First of all, before launching any conservation programme, one has to decide on the appropriate **founder animals** contributing the genetic material to the **first generation** of an *in-situ* conservation scheme (Toro and Maeki-Tanila, 1999). The initial sampling of animals should maintain the maximum genetic variability present in the breed/subtype (Toro and Maeki-Tanila, 1999) but that constitutes the first problem. Due to missing genetic and morphological analyses of cattle in the research area and in particular with focus on differences within the Borana breed, to have the most distinct animals that can be taken as founder animals is not feasible. The animals upon which the entire conservation plan will be based must be chosen according to morphological appearance and expert opinions of local livestock-keepers.

An equity problem might arise in the region/country where a community-based conservation programme will eventually be initiated. Valuable genes and genetic traits can be captured by purchasing only a few animals for the **founder stock** of the conservation programme. These few animals are first of all identified based on **morphological traits** and secondly, if the budget allows it, a **genetic analysis** of the DNA of these founder animals is desirable. The problem of **equity** arises because the conservationists have to decide from whom to purchase the desirable animals assumingly at a relatively high price. Additionally it is wise to further assume that the owner of these animals will be at the same time one of the participants (that would be advantageous in terms of transaction costs[123]) and hence the owner will obtain further benefits coming along with the conservation programme (e.g. compensation payments etc.). Mendelsohn (2003) argues that because the genetic material is effectively **co-owned**, there is an incentive for all the owners to underbid each other trying to get the sale. As a result, the generic genetic resource in the breed will tend to be undervalued. No single owner can obtain the value of the resource as long as the other owners exist. Competitive markets will therefore fail to preserve valuable genetic stock. Mendelsohns' apprehensions should be taken into account when setting the price at which the animals for the founder stock will be purchased.

Taken, that it has been decided on the Borana subtype that should be conserved, the area, communities and participating households as well as on the number of cattle that each

[123] Either the owner of the potential founder animals resides in an area where the conservation programme could well be carried out and could then be one of the participants or the best suitable founder animals are found in a different region. In that case they need to be purchased from these livestock-keepers and simply transferred to a region where the conservation programme should take place. If animals that are suitable for the founder stock are found in a desirable region then the owner might possess cattle of various other breeds and might need compensation for dismissing them.

household should maintain, the question of initiating the conservation process finally comes up. Considerations as follows thereby arise:

- How to distribute cattle to livestock-keepers?
- How to monitor the success of the conservation programme in the future?
- How much staff should be involved for monitoring, who provides the staff?
- How and where can livestock-keepers be met to exchange information?
- What would be the degree of punishment if it comes to breaches (e.g. household sell cattle or allow crossbreeding)?
- How large should be the geographically dispersion of conservation herds?
- How long should the conservation programme be funded and when is monitoring enough and the Borana population can be left alone without the fear that in a few years time the situation will worsen again?
- If the problem of maintaining cattle in general lies in the changing lifestyle livestock-keepers nowadays and in particular coming generations pursue (e.g. increased urbanisation, increased education and hence opportunities to take on other employment) and the pastoral life and cattle production will be gradually abandoned, how can the government or other institutions intervene and is a intervention justified in the first place?

The just mentioned considerations give a first impression that there is a lot of research that still needs to be carried out. Further research following up this economic valuation includes genetic analyses using **molecular markers** in order to **assign genes to particular traits** of Borana cattle. The only genetic value that was made use of in this research was the calculation of extinction probabilities. This study lacks proper genetic values such as genetic diversity within the Borana breed, i.e. between the relevant Borana subtypes, but it gives a base for further research. The findings of this study (in particular the monetary values of single attributes and entire breeds) could be well incorporated into livestock management programmes and **breeding software** that is used for optimising breeding programmes. For some Borana subtypes (mainly EB and KB[124]) blood samples have already been collected and analysed at ILRI laboratories and this data could be implemented into the economic model. But that is still too little data and the genetic data needs to match the animals/the subtypes from which economic values were derived. Genetic analysis from the SB, for instance, is until

[124] So far complete data sets on Borana genetics only exists from commercial ranches where Borana are crossed with Holstein Frisian, for instance, but genetic data based on blood samples from Boran cattle in remote areas in Southern Ethiopia and northern Kenya is still poor.

now utterly missing keeping scientists in the dark about the similarity of SB and EB. Furthermore, in order to assess genetic values relative to other existing breeds, molecular analysis is also required for the SEAZ in northern Kenya and the Guji and Gari in Ethiopia and in general of any other breed that co-exists to the Borana.

A better understanding of the genetic value of the local Borana subtypes could also help to tackle the question on the **property rights**. Knowing how much of the high performance is due to the genes that were initially created by local livestock-keepers on the Borana plateau centuries ago might eventually lead or at least justify benefit transfer to and share with the original owners of this cattle breed. **Benefit sharing** is a further major key point that needs further research emphasising on AnGRs. From the topic of plant genetic resources, it is commonly found that the more people use them, the better it is for their conservation. Exporting Borana genes to Western country attracted more users but at the same time proper benefit sharing with local users and those how should be the legitimate owners of the AnGRs and who provided the Borana genetic resources in the first place should be secured.

In an extreme scenario one could argue that due to the fact that Borana genetic material has already been **exported** to other African countries and also to some Western countries, there is no need to conserve the Borana breed in its original habitat anymore. From a strict conservationist’s point of view it would be enough to cryogenically store Borana genetic material in Australia or the USA where the genes have been exported and where the Borana breed has been further improved. This suggestion would of cause call into action property rights claims and livestock-keepers in the Borana zone who should be the “legitimate” owners of the Borana breed would not benefit at all (see also Chapter 7.2.3). What is true, however, is that due to these exports, the Borana breed lost its **uniqueness** and Kenya and Ethiopia lost their exclusive status of hosting a unique breed. An extinction of Borana cattle in Kenya and Ethiopia would not signify the perishing of the genetic material, as it still exists in other countries. It is doubtful, though, that the exported Borana animals still contain the original genetic material, in particular in Australia and USA where intensive improvement breeding has taken place. Borana animals that were taken from their natural habit and are now kept in intensive production systems with unlimited water und fodder supply, proper stables and veterinarian service are not able to develop and maintain their adaptability anymore. Due to **selection pressure** over time their offspring will lack or at least dilute the adaptive traits that are so unique for the Borana.

Research on **transaction costs** of conserving AnGRs is still in its infancy as well. Tackling many small units (as suggested 100 households) certainly increases the transaction costs because the animals that should be conserved need to be allocated and monitored. One way of minimising these transaction costs would be to ask livestock-keepers to collect the animals that should be conserved, exchange them and track them back. The transaction costs for monitoring the entire conservation programme by **external agents** are immense when 100 households are involved. One solution would be to target 100 households in the same community or nearby communities because the animals could then be congregated and monitoring would be facilitated. Using one common pasture should, on the one hand, ensure **minimal level of crossbreeding** with other breeds and better monitoring, but on the other hand such an approach would appear more to **on-station** *in-situ* conservation and not community-based. An on-station programme can be visualised as a kind of "putting a fence around a huge pasture with only pure Borana cattle". Doubts about this kind of approach might arise due to the difficult implementation. Further research is needed in this manner to make precise statements about advantages and disadvantages of on-station versus community-based programmes. No experiences in on-station strategies exist for FAnGRs, but lessons could be learned from wildlife conservation where such protection measures have already been installed (e.g. zoos).

As a further discussion point, it is noteworthy that the assessment of costs of *in-vivo* but *ex-situ* conservation or even cryoconservation of AnGRs and indigenous breeds will become more important in the future. For the case study of the Borana breed, an *ex-situ in-vivo* strategy is similar to on-station conservation but outside the natural habit of the Borana lowlands and without local livestock-keepers being involved. After the **drought** that apart from northern Kenya and southern Ethiopia recently[125] also disastrously hit Somalia and Djibouti new directions towards possible *ex-situ* conservation programmes must be considered. When, despite the superior adaptability and hardness of valuable local breeds, these breeds while being conserved in a community-based programme eventually all fall prey to a serious drought, the question remains whether these local breeds are worth to conserving *in-situ.* The so disdained *in-vitro* and *ex-situ* conservation of live animals might, despite all the doubts, bear some competitive advantages to the *in-situ* strategy, namely that of better **risk control** and **dispersion**. *Ex-situ* conservation is usually more **complex** and hence the likelihood of its successful implementation might be lower than for *in-situ* strategies. On the other hand, *ex-situ* conservation programmes are less **risky** because live animals and genetic

[125] In December 2005, the UN firstly announced that a new drought has hit East Africa. The drought had its peak in March 2006, when the UN announced that at least 100 million of people are in peril of starvation and 70 per cent of livestock to have perished. In May 2006 some rain fell and the drought was assumed to be over.

material are dispersed in many locations/regions. In this case the populations of animals in the conservation programme are not as vulnerable against catastrophes as in *in-situ* programmes. A further crucial disadvantage of *ex-situ* conservation is, as already mentioned, the lack of the ability to gradually maintain the adaptability to harsh environments. From a cost-effective point of view it is reasonable to combine *in-situ* and *ex-situ* programmes. An *in-situ* conservation programme could be carried out in an area/country in which it would come along with low costs but large benefits (as in Ethiopia) and at the same time an *ex-situ* programme could be implemented in other area(s), that are less vulnerable to droughts and epidemic diseases (e.g. in the Kenyan highlands).

7.5. Summary

This chapter aimed to finally decide which Borana subtype should receive priority in conservation. Therefore, the Weitzman approach was applied and perceived as an appropriate tool for making decisions about cost-efficiency of breeds for conservation. In this study the Weitzman theorem was only applied to the three relevant Borana subtypes but it has potential to be extended to other breeds, enabling the comparison of "conservation potential" among breeds of farm animals.

The Weitzman theorem made use of two criteria that were estimated in previous chapters of this study: utility and costs of Borana subtypes. A third criterion was included and calculated in this chapter: the extinction probability of the three Borana subtypes. Based on these three criteria ranking scores were calculated. As a result it was revealed that the EB subtype possesses the highest ranking score and thus shows cost-efficiency compared to the other subtypes. In terms of cost-efficiency it was further suggested to refrain from conservation programmes for the Borana in Kenya but to allocate scarce financial recourses to programmes that will be launched in southern Ethiopia.

The second aim of this chapter was to outline some practical issues related to conserving the Borana. First of all, the study suggests that the optimal ratio that is also feasible to manage from a livestock-keepers' perspective is the conservation of 1000 Borana cows and 100 Borana bulls. 100 households should be asked to participate in the programme, i.e. 11 animals should be allocated to each household. The welfare gain for the households and the costs that will arise from different settings for community-based *in-situ* programmes are highlighted in this chapter. Further, this chapter provided potential benefits of community-based *in-situ* conservation but also a few drawbacks and considerations that should be taken into account before the implementation of this strategy. Incentives for local livestock-keepers in form of compensation payments and incentives/benefits created by the market were pointed out in particularly. It was commented that compensation payments must be finite while other incentives/benefits created by the market lead to self-sustainability of a conservation programme. The two main disadvantages of community-based *in-situ* conservation - risk dispersion in disastrous situations and arbitrariness of transaction and monitoring costs - were highlighted.

CHAPTER EIGHT

Concluding remarks and discussion points

8. Concluding remarks and discussion points

The CBD and CGRFA constitute a first step in raising awareness for the need of conserving agro-biodiversity in order to overcome the threat of dwindling genetic resources. Due to the hitherto absent economic value for agro-biodiversity, conservation initiatives fail to compete in policy decisions and in fund raising issues. This empirical study provides a comprehensive picture of the conservation of FAnGRs, thereby focusing on a particular cattle breed original to northern Kenyan and southern Ethiopia: the **Borana**.

The study includes the recognition of the **economic value** of local cattle as conservation justification and for guiding breeding schemes (Chapter 5), as well as the **costs of the conservation** of the pure Borana breed (Chapter 6). The study finally shows **ranking positions** for cost-efficient conservation of the three relevant Borana subtypes relative to each other and in cross-national and production system specific contexts (Chapter 7). Thus, this study addresses various questions in a quantitative way that dominates the current considerations for conservation policies of AnGRs: "what to conserve?", "how much to conserve?", "where to conserve it?", "who should conserve it?" and how much does the conservation costs?".

The methodical approaches and economic tools vary according to these questions, but are mostly confined to stated preference methods: choice modelling and contingent valuation. It is worth mentioning that the assessment of economic values was done at two levels, on the one hand at attribute-level and on the other hand at breed-level. Monetary values were derived for each Borana subtype. The costs analysis only deals with breeds and is not specified for all Borana subtypes but is for the EB only. The calculation of the priority for conservation was also carried out for different Borana subtypes, based on the Weitzman approach.

8.1. Conclusions

This section casts some light on the main results of the Borana cattle case-study, separated by various key issues that were found to be important when outlining an overall picture of conserving AnGRs.

8.1.1. Threats

The Borana breed was considered as research "object" due to two reasons. Above all, it was expected that the Borana would be of immense value to local livestock-keepers because it was known that almost all people in the research area largely, if not entirely, depend on livestock production. The entire traditional nomadic lifestyle of local livestock-keepers depends on the breeding and husbandry of Borana animals and *vice versa* without this production system Borana cattle would not be that important in the research area. Secondly, it had already been assumed that the Borana breed and also other cattle breeds had to face multiple threats and that their numbers were declining. However, it was left to the research to verify these assumptions and to expose the real threat to and benefits of the pure Borana breed.

Declining availability of pastures and the abundance of the traditional nomadic production system are the major threats for the survival of cattle in the research area in general. Increasing **crossbreeding** in both countries further put the survival of the pure Borana breed into jeopardy due to genetic dilution. The study reveals that many driving factors for the genetic degradation of the Borana breed and a decline in its population are partly **country-specific**. In Ethiopia the crossbreeding is mainly pursued as a consequence of the lack of pure Borana animals for mating and hence, other inferior local breeds are used for restocking and reproduction, gradually replacing the large-framed pure Borana breed. The dominant factor in Ethiopia causing a lack of good pastures is the increasing bush encroachment, resulting in huge areas becoming unsuitable for cattle grazing. Hence, rivalry for this scarce pasture and water exists between cattle and other different domestic animal species. Since cattle are grazers, they are in danger of being replaced with browsers, such as camels and goats, which are better suited to areas with heavy bush encroachment. Such species substitution threatens the Borana way of life in Ethiopia and leads more and more to permanent settlement which is more suitable for goat husbandry.

In Kenya, the breeding objectives seem to be very advanced given the improving infrastructure and linkage to Nairobi markets. The **opening up of market**s contributes to further genetic erosion of Borana cattle because livestock-keepers are then able to substitute the Borana with other more productive breeds. It was found that, until now, the crossing of Borana breeds with improved high-yielding breeds is in its infancy but a trend towards this development can be revealed. In Kenya, adverse **political decisions** further promote crossbreeding programs and the **abundance of traditional herding** altogether, leading to a further reduction of Borana cattle.

It can be concluded that in Ethiopia the problems are more environmentally driven whereas in Kenya the main threats are caused by market and political forces. Further, it is worth mentioning that the main problem with regard to the Borana breed is not the decline in numbers of this breed but rather its genetic erosion.

8.1.2. Benefits

The benefits of Borana are well-known beyond the borders of East Africa and are well documented in literature. The Borana breed, like any other cattle breed in the research area, contributes largely, if not entirely, to livestock-keepers' **income**, wealth status and their daily **food supply**. Cattle are, compared to small stock, rather perceived as "**insurance money**" than "cash money" and are usually only sold for meeting larger expenditures. These benefits in which livestock-keepers ranked the Borana breed as superior to other breeds are the immense cultural significance and the excellent adaptation ability to the harsh environment of the Borana lowlands. Conserving the Borana breed helps to maintain the Borana people's traditional way of life and secured food supply and with it a sustainable way of animal production in these semi-arid and desert-like areas of the Borana land.

8.1.3. Value

The economic valuation is necessary to give a first glance at whether a breed is "worth" receiving **priority in funding** for conservation. Being able to define separate monetary values for attributes also contribute to **breeding** schemes. Indigenous livestock breeds are subject to the fact that it is very difficult to capture their "real" price on the market. **Market failures,** including extreme poverty in the Borana lowlands, oligopolistic market behaviour as well as simple non-availability of pure Borana cattle on the markets forbid the reflection of a "fair" price or value of Borana, Hence this study avails itself of a **stated CE** aiming to indirectly elicit values of attributes and entire breeds.

The CE seeks to define values for **attributes** of cattle as they are perceived by livestock-keepers. The higher the value for an attribute, the higher the livestock-keepers' **utility** from animals expressing such attribute and their **WTP** are. Negative signs of values signify negative utility due to forgone benefits and negative WTP, herein defined as **OC**.

Seven attributes were initially identified and were assigned different levels of expression prior to the survey and the conducting of the choice experiments upon which the indirect utility function for bulls and cows were based. The seven attributes characterise the productive, adaptive and cultural constitution of cattle. Carrying out a **choice ranking** experiment - grounded on the economic theory of Lancaster's consumer choice and Mc Fadden's random utility model, the indirect utility functions, one separately for bulls and one for cows - was estimated, bearing in mind livestock-keepers' utility maximisation from the purchase of cows and bulls. To create the experimental design forehand, the statistical package SPSS and its procedure of **fractional factorial orthogonal design** were chosen. The data was obtained from interviewing 370 households in northern Kenya and southern Ethiopia and it was opted for two economic models that were eventually estimated in LIMDEP 8.0 Nlogit 3: a basic MNL model and an extinction of it, a MXL model.

Table 34: Results of the MNL model – WTP values for single cattle attributes

Attribute	Value for bulls (in € per animal)	Value for cows (in € per animal)
"Watering once in 3 days"	12	9
"Watering once a day"	-62	-39
"Tick tolerance"	24	16
"Big body"	6	8
"Fertility"	21	17
"Short and straight horns"	-7	Not important
"Long and curved horns":	-12	Not important
"Traction suitability"	47	-
"0-2 litres daily milk yield"	-	-12
"> 4 litres daily milk yield"	-	-6

As inferred from the basic MNL model presented in Chapter 5, many attributes have **enormous value** from a livestock-keepers' perspective. Deriving welfare measurements such as WTP estimates revealed that **productive traits** are not among the most "valuable" attributes but rather **adaptive traits** such as tick tolerance and the capability of withstanding water shortage up to three days. **Cultural values,** such as the horn appearance, were expected to have higher utility for local livestock-keepers but they were rather indifferent towards this attribute (especially true for horns of cows), rating them less important than other adaptive and productive attributes as decision drivers. The body size, with large animals standing for the wealth of a herder, had a positive value, but not as great as other attributes. To summarise, the attributes and their estimated WTP for them are listed in table 34 (with all values being significant at the 95% confidence level).

The WTP estimates are strikingly similar in Ethiopia and Kenya for some attributes (in particular for attributes of cows) but nevertheless **country-specific** differences among livestock-keepers' WTP could be detected. The major differences were:

- In Kenya, livestock-keepers do not place any value on the body size of bulls
- In Ethiopia, "tick tolerance" is valued more highly for bulls and cows alike (10€ more per bulls and € more per cow)
- In Kenya, "strong offspring" is valued 7€ more per bull
- In Kenya, livestock-keepers are indifferent towards the horn appearance in bulls

- In Ethiopia livestock-keepers are indifferent toward the daily milk yield of cows
- Only in Ethiopia do horns play a significant role for cows

Besides country-specific models, separate partworth values for each production system were estimated as well. Livestock-keepers in the research area usually pursue either pure pastoralism, meaning that they depend almost entirely on livestock production (at least to 80 percent as per definition) or are engaged in agro-pastoralism (i.e. 50 percent of their income is derived from crop production, 50 percent from livestock production). It was suggested that there are different perceptions for attributes and their utilities among livestock-keepers in different production systems and that a shift from traditional pastoralism to agro-pastoralism contributes to a large extent to dwindling AnGRs. This study sheds light on whether this is in fact the case for livestock-keepers in the research area. The results reveal that the following **production-specific** differences are of key importance:

- Agro-pastoralists consider the ability to withstand water shortage for up to three days for bulls as an unimportant trait, and
- Agro-pastoralists consider the ability to withstand water shortage for up to three days for cows less important than pastoralists do.
- Agro-pastoralists prefer "short and curved horns" whereas pastoralists are totally indifferent towards the size and the shape of horns of bulls.
- Agro-pastoralists and pastoralists are equally indifferent towards the attributes "> 4 litres milk yield" and "short and straight horns" in cows
- Only agro-pastoralists show positive WTP for large-framed animals whereas pastoralists' preferences are not driven by the body size, neither of bulls nor of cows

Applying an extension of the MNL model, a MXL model that allows for individual characteristics to vary randomly between interviewees (i.e. enabling to explore how preferences vary across household composition), gave evidence that livestock-keepers in the research area were quite **homogenous** in their perceived utility for cattle. The decision about selecting animals due to the expression of various attributes did not appear to be influenced by livestock-keepers' socio-economic background such as the level of education, social recognition, and age of the head of household. In general, parameters indicating the "wealth" of households could not be detected as a possible source of a difference in livestock-keepers preferences for cattle attributes. The only parameters varying among livestock-keepers that could explain some of the differences in preferences were the "country", "household size", "production system", "herd size", and for the cow model additionally, "market linkage" and "access to arable land".

Knowing how livestock-keepers with different socio-economic background differently value cattle attributes can contribute to the **targeting of participants** for conservation programmes for Borana cattle, namely targeting of those who derive the highest utility from the pure Borana and hence whose participation would have been most cost-efficient. However, only a few socio-economic characteristics were found to have any impact on the preference for cattle attributes at all. Among the most significant factors were the differences in production system and in the country.

Apart from elaborating the values of single attributes, this study also aimed the monetary assessing of breeds and Borana subtypes *per se*. Due to the confusing and literally non-existing **classification system** for cattle breeds in the research area it was very tricky to define **net values** for a breed *per se*. This problem was solved by conducting **scenarios**, in which various Borana subtypes with their unique characteristics were **simulated**. Running the MNL model on these scenarios permitted the prediction of WTP values that livestock-keepers would hypothetically assign to the breeds described in the scenarios. The resulting values were equal to livestock-keepers' COS for the relevant subtype, i.e. the values they were willing to pay for changing from the status quo breed to one of the Borana subtypes. The results of the simulation procedures revealed the following COS values:

Table 35: Results of the simulations – Compensating surplus for Borana subtypes

Borana subtype	Value for bulls (in € per animal)	Value for cows (in € per animal)	Overall value (in € per animal)
OB	364	186	**204**
EB	388	234	**249**
SB	306	241	**248**
KB	260	188	195

The values indicated in Table 35 are pooled for Kenya and Ethiopia and the far right column shows the value averaged over sex with a ratio of nine cows to one bull. It is further worth mentioning that in Ethiopia the values were all lower in general and that Kenyan livestock-keepers assign the highest value to the SB and not to the EB. The values for Borana crosses and other local breeds such as the SEAZ were found to be considerably lower in both countries than the values for the Borana. A production system specific glance at the values brought to light that agro-pastoralists assigned lower values to all four Borana subtypes than pastoralists. Eliciting the values for EB, OB and SB is crucial because these are the three subtypes that should be potentially conserved. These values constitute an important part for setting up ranking priorities for conservation.

8.1.4. Costs of conservation

Carrying out a CV seemed to be most rewarding in capturing the costs of compensation of the pure Borana and to, first of all, get an idea about livestock-keepers WTA any compensation at all. The CVM used the measure of WTA compensation for exchanging the livestock-keepers' current breed by the EB breed (representative for the pure Borana). The costs of the conservation of EB are thereby defined as the costs of substitution of breeds and the resulting OC for forgone benefits due to this exchange. It was thereby assumed that a change from respondents' status quo breed to the EB would results in lower utility for them and that hence livestock-keepers were not allowed to state negative WTA values. Negative WTA compensation values were simply treated as zero WTA. The findings of this study suggest that the costs will be different for both research countries. The absolute mean costs per animal per year were showed to be as follows:

Table 36: Costs of the conservation of the EB subtype

Condition for conservation programme	Costs (in € per animal per year)
Overall	**26.2**
Ethiopia	7.3
Kenya	61.8

The conclusion of the cost analysis further showed that the application of a GMA could not recommended for defining costs for *in-situ* conservation of AnGRs, at least not in the case of the Boran breed.

8.1.5. Priority ranking

Only bearing in mind livestock-keepers' preferences and absolute costs as justification for conservation and to address the question of "what to conserve" might not be sufficient enough but rather it is recommended to include the concept of **cost-efficiency**. The Borana subtype with the highest outcome (in terms of genetic and economic values) per unit of conservation cost should be given the highest priority for conservation. As economic values, livestock-keepers WTP indicators based on their preferences were taken into account while genetic values needed to be additionally assessed. The previous costs analysis provided the required figures for the costs of conserving the EB. It was simply assumed that the costs would be the same for EB, OB and SB. With regard to genetic values, the study was constrained to the measure of **extinction probability** as a proxy for endangerment and the "urge" for conservation.

Ranking scores were calculated by applying the **Weitzman theorem**. This formula enabled the determination of a score for each of the relevant Borana subtypes, under the consideration of cost-efficiency. The score of each subtype were compared and the result implied that it would be cost-efficient to conserve the **EB type**. The SB should be given the second priority for conservation and the third priority for the OB subtype. In Ethiopia the OB was ranked second behind the EB with the SB third while in Kenya, the order was detected to be the same for the pooled dataset: EB before SB before OB. The scores for all three Borana subtypes were in general quite low compared to those in Ethiopia. The highest score and thereby the highest priority was received when conserving the EB only in **Ethiopia.**

This result is cohesive with the preceding results of the MNL model. Including genetic factors and elaborating on cost-efficiency rather than on absolute values does not move away from the notion that the EB in Ethiopia is the subtype that shows the highest potential for conservation.

8.2. Community-based in-situ conservation programmes

The advantage of community-based *in-situ* over on-station *in-situ* is the **property rights** aspects. Those communities and cultural groups who initially provided the genetic resource of the Borana breed can benefit from conservation initiatives in form of additional income generation through compensation or ideally after some years through incentives provided by market forces (e.g. premium prices for Borana products).

Chapter 7 of this study provided an overview of different scenarios of how the Borana breed could be conserved and it came to light that one scenario that was entirely grounded on the results of the CV would lead to conservation at **zero costs**. This can be archived by targeting those livestock-keepers who stated that they did not to need any compensation at all for substituting their cattle by EB (that were 80 percent of Ethiopian respondents and 62 percent for the pooled data set).

Looking separately at both countries however, targeting Ethiopia livestock-keepers is the more cost-efficient option than targeting Kenyan people. For a successful conservation programme it is important to know **how many animals** should enter a programme. This study made use of the **SMS** and concluded that 1000 pure Borana cows and 100 Borana breeding bulls would be sufficient to secure future breeding goals. Bearing in mind the average number of cattle that each household can stock, **100 households** should be embedded into community-based conservation programmes, each conserving 10 cows and one breeding bull. Thus, the total numbers of Borana animals that are required for a founder stock are **1100**.

Conserving 1100 animals of the EB subtype in Ethiopia would lead to total costs of €8,030 per year. These costs are only costs in form of compensation payments to participating households that exchanged their breed for the EB breed. If a conservation programme in Kenya were to be launched, the results of Weitzman's theorem indicated that it would be most cost-efficient to conserve the SB and hence, total annual costs of €67,980 would emerge.

8.2.1. Policy implications

Conserving AnGR is not a goal in itself, but a means of maintaining the potential benefits accruing from the conserved resources both now and into the **future**. Therefore, to make a judgment as to the appropriate level of **investment** in conservation, the utility of AnGR has to be valued and considered in light of the cost of their conservation. It is important that not only conservation programme **costs** are taken into account, but also the livestock-keepers' willingness to conserve the targeted breeds. As shown in the cost analysis, a large share of livestock-keepers would not ask for compensation payments at all and a sound policy for a community-based programme should make sure to tackle these individuals in the first place. A survey prior to the implementation of a conservation programme is hence recommended.

Implications for conservation can be drawn from the CE. Above all, from the basic MNL results it can be inferred that many attributes for which the Borana breed is known are perceived as significant and very valuable by local livestock-keepers. This alone gives rise to a **justification** of this breed's conservation since they are most likely to require compensation payments for forgone benefits arsing through conserving the Borana.

Having an approximate idea of the conservation cost of a single Borana, further permits the application of a SMS approach that can enable government and private parties to launch *in-situ* conservation programmes capable of ensuring the continued existence of a sufficiently large pure Borana cattle herd, as well as contributing to livestock-keepers livelihoods.

It was found that the Borana breed faced various threats and that these threats have different origins in Ethiopia than in Kenya. Particularly in **Kenya**, where the threats are largely triggered by political and market forces, and where the attitude of livestock-keepers towards high-yielding improved breeds (including exotic breeds) is more developed than in Ethiopia, policy (which policy?) should keep an eye on the development of market prices for cattle products because **market incentives** (e.g. certification for Borana products as premium products) can constitute an effective tool for conservation and minimise its costs. Until now, Kenyan **legislations** and institutional settings have had adverse effects on the conservation of AnGRs. In **Ethiopia**, on the other hand, livestock-keepers seemed rather to be driven and to some extent constrained in their attitude toward cattle breeds and purchase behaviour by the changing **environmental conditions** and the simply **non-availability** of Borana breeding material for improvement of their cattle. In this case, the implications would be to overcome environmental problems in order to enhance proper cattle production in the first place. One major advantage for Borana conservation would be to secure the availability of good **pastures** to communities. Removing undesirable **bushes** might be a further option as well. This has particular relevance to Ethiopia where the lack of pasture due to intensive bush encroachment constitutes a major constraining factor for any conservation programme. Secondly, the establishment of **functioning markets** and the better **access** for local livestock-keepers to pure Borana animals can lead to de-facto conservation. Ethiopian livestock-keepers have high utility from the pure Borana breed but its adverse **distribution** and non-existence in some areas do not allow livestock-keepers to keep and maintain it.

Many scientists in the developed world think that pastoralists would be keen to give up their **traditional lives** but the findings of this study could not confirm this statement. It is true that some livestock-keepers shifted their production strains entirely to crop production (and in particular in Kenya to cash crop production such as **miraa**) and their families often migrated to urban areas, but in general, livestock-keepers try to stay in their traditional system and adapt to new situations. Governmental activities should not be laid out in such a way that livestock-keepers are more or less "urged" to sedentarisation (with families and animals) but they should promote traditional pastoral lives in order to maintain sustainable resource management and to prevent overgrazing etc. Livestock-keepers adapt to new developments in their own way (e.g. by using mobile phones to gather market information and weather conditions) as necessary while still maintaining sustainable livestock production based on the division into *foora* and *waara* migration but the institutional situations often do not allow for this. Without pastoralists large areas of the Borana lowlands cannot be used at all and will eventually be abandoned.

As amply shown by the case study of the Borana breed, without a defined **property rights** scheme, genetic flow beyond the origin country of the genetic resource is unavoidable. It is now too late to set up policies that enable benefit sharing and that compensate livestock-keepers who have stewarded and developed the Borana breed over centuries but this study might raise the awareness for other cases in which intense genetic flow is expected to soon take place. Under the umbrella of the **CBD** and the and the **CGRFA** sound property rights and benefits sharing policies might be soon implemented for breeds other than the Borana that experience great recognition from other countries and that are due for global in-and exports.

8.3. Directions for further research

In conclusion, this study amply verified the usefulness of multi-attribute stated-preference methods, such as CE and CVM, as a way to investigate non-market and market preferences over cattle attributes and breeds as perceived by local livestock-keepers. However, **information** was missing with respect to the **genetic value** of the Borana subtype that should receive priority in conservation funding and on costs other than OC and compensation payments. Further research is needed in the field of **transaction costs**. This study mainly assumed neglectable transaction costs for local livestock-keepers but other transaction costs for external institutions fostering the conservation programmes might be quite high. Albeit the costs were found to be quite low, but there is still the fear that conservation programmes will eventually be more hampered due to problems related to the initial implementation, the management and continuous monitoring. Hence, only allocating the required budget will not be sufficient but continuous monitoring will be necessary. Costs in form of transaction costs can not be predicted and they strongly depend on the time horizon of a conservation programme. Again, more research should be addressed in this field.

Using the Weitzman approach for placing ranking scores on Borana subtypes was subjected to **two assumptions** that are both prone to criticism: first of all it was assumed that the costs were the same for all subtypes and, secondly, missing molecular analyses did not permit the assessment of the genetic diversity within the Borana breed. Weitzman's theorem is largely based on the dissimilarity of breeds/species but in this study it had to been assumed that there was no genetic dissimilarity between the Borana subtypes. Conducting molecular analysis was very time-consuming and cost-intensive and it will hardly been performed for detecting dissimilarities within one breed. Even molecular analysis between breeds is still in its infancy and not yet completed for all farm animal breeds in developing countries. Without genetic analysis however, conservation initiatives for the Borana will be hampered because as founder stock it will be crucial to include the "pure" EB animals upon which the entire conservation programme will be finally be based. Hence, future research in the filed of molecular analyses must not omit the diversity within breed.

This study further recommends a rethinking in the proper selection of **conservation strategies** and to give more credit to the potential of *ex-situ* conservation. That is because community-based *in-situ* conservation is very vulnerable to losses due to catastrophes, whereas with the combination of *in-situ* and *ex-situ* programmes, the risks can be better dispersed. There is definitely more need for research on eliciting *ex-situ* conservation costs per animal and on the possible implementation and management of *ex-situ* conservation of

AnGRs in developing countries. With regard to *ex-situ* conservation, it would also be of interest to reveal other values than those with internal effects for local livestock-keepers. The conservation of AnGRs has some positive externalities. The use of Borana genetic material for future breeding programmes and as insurance is also beneficial to breeders, researchers and conservationists outside the research area. Quantifying non-use values of the Borana breed (such as its existence and bequest value) can guide policy decisions for *ex-situ* conservation programmes.

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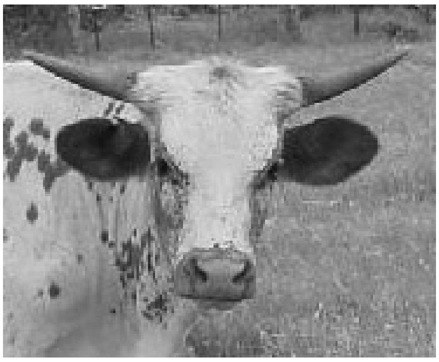
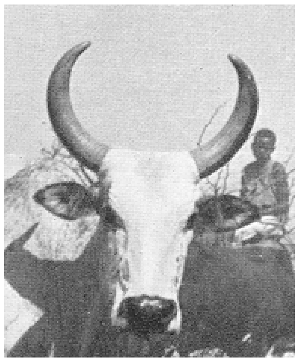
Appendix

Figure 10: Descriptions of horn size and shape according to levels used in the choice sets



short and straight horns
(horn_1)

short and curved horns
(horn_2: the status quo)



long and curved horns
(horn_3)

Figure 11: Example of a choice set for bulls

Card 13	Card 20	Card 25	No animal
Male cattle, age 5 years			Not buying animal but keeping the money
Progeny: **weak calves**	Progeny: **weak calves**	Progeny: **strong calves**	
Body size: **big frame**	Body size: **small frame**	Body size: **small frame**	
Tick tolerance: **good**	Tick tolerance: **poor**	Tick tolerance: **poor**	
Traction: **suitable**	Traction: **unsuitable**	Traction: **suitable**	
Watering frequency: **once in 3 days** day1 day2 day3 Water	Watering frequency: **once in 2 days** day1 day2 day3 Water Water	Watering frequency: **once a day** day1 day2 day3 Water Water Water	
Horns: **short and straight**	Horns: **long and curved**	Horns: **short and straight**	
Price: **900 Birr**	Price: **900 Birr**	Price: **1200 Birr**	

Figure 12: Example of a choice set for cows

Card 7	Card 26	Card 19	No animal
Female cattle, age 5 years			Not buying animal but keeping the money
Calving frequency : **once a year**	Calving frequency : **once in 2 years**	Calving frequency : **once a year**	
Body size: **big frame**	Body size: **small frame**	Body size: **small frame**	
Tick tolerance: **poor**	Tick tolerance: **good**	Tick tolerance: **poor**	
Milk yield: **2-4 litres** 2-4 liter	Milk yield: **more than 4 litres** > 4 liter	Milk yield: **0-2 litres** 0-2 liter	
Watering frequency: **once in 3 days** day1 day2 day3 Water	Watering frequency: **once in 2 days** day1 day2 day3 Water Water	Watering frequency: **once in 2 days** day1 day2 day3 Water Water	
Horns: **short and straight**	Horns: **short and curved**	Horns: **long and curved**	
Price: **800 Birr**	Price: **800 Birr**	Price: **600 Birr**	

Figure 13: Borana cows, conserved on an Ethiopian governmental ranch

Source: own photograph

Figure 14: Borana bulls (OB type) with ploughs

Source: own photograph

Figure 15: Borana cow (EB type)

Source: own photograph

Figure 16: A good example for a breed falsely dubbed Borana

Source: own photograph

Figure 17: A herd of very heterogeneous animals (SEAZ and OB)

Source: own photograph

Figure 18: An example for an improved Borana bull; used as breeding bull on a South African commercial ranch

Source: http://clynton.collettgroup.com