ECONOMIC BENEFIT AND WILLINGNESS TO PAY FOR IMPROVED RANGELANDS IN UGANDA

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DECLARATION

I hereby declare that this report is my own work and has never been submitted to any University for the award of Masters Degree in Agribusiness management.

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DEDICATION

To my father and mother, Christopher and Joyce Mukama who in their wisdom decided to forego a number of pleasures at their demanding youthful stage to pay for the education for myself and all my siblings.

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I take this opportunity to thank all those whose effort and wishes have made this work a reality. In particular, my appreciation goes to my supervisors; Prof. Bernard Bashaasha and Prof. Charles Waiswa who guided me in producing this piece of work. A lot of regards go to all my lecturers of the department of Agricultural Economics and Agribusiness. I cannot forget Mr. Bwire who introduced me to Strategic Planning and Management which has greatly transformed my way of doing things. I am also privileged to have been tutored by a renowned Professor of Economics, Hertzeler, at the Center for Environmental Economics and Policy in Africa (University of Pretoria) whose first assignment of writing a Research Proposal was used to develop this thesis.

I pay tribute to my wife whose unconditional love and support inspired me to complete this course which was not easy as a family-sponsored student and worker. My children, Ivan, Carol, Miriam and Kenneth have always challenged me to produce an end of term report just as I always demanded the same from them. Chris is another one whose pranks always kept me awake and fresh for late reading.

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LIST OF ACRONYMS

CEEPA	Centre for Environmental Economics and Policy in Africa
CVM	Convergent Valuation Method
ER	Expected Revenue
GDP	Gross Domestic Product
IDDP	Integrated Dry lands Development Program
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MUC	Marginal User Cost
NB	Net Benefit
NEMA	National Environment Management Authority
NLPIP	National Livestock Productivity Improvement Project
NPV	Net Present Value
PS	Producers' Surplus
QB	Quantity of Biomass
ROC	Receiver Operating Characteristic
TEC	Total Effort Cost
THH	Total number of Households
TMUC	Total Marginal Cost
TP	Total Population
TUC	Total User Cost
TWP	Total willingness to pay
UBOS	Uganda Bureau of statistics
UG	Uganda
UNCCD	United Nations Convention to Combat Desertification
WTP	Willingness to Pay

ABSTRACT

Soil degradation, due to overgrazing and deforestation, is a serious productivity and environmental problem in the ***rangelands* of Uganda's** cattle corridor. The ***rangelands*** cover about 43% of the country's total area and supports 65% of the livestock population owned by 60% of livestock keepers. This phenomenon is attributed to communal ownership and open access to grazing resources (pastures and water) practiced by pastoralists and agro-pastoralists in these areas.

To design appropriate strategies for rehabilitation and maintenance of the resource, comprehensive regular updates of information on the people and on the rangeland ecologies are necessary. A field survey using Contingent Valuation and Dynamic Simulation Model Methods were used to gather the vital information from Mbarara, Nakapiripirit, and Nakasongola where pastoralism is widely practiced; and Mukono where arable agriculture is the dominant feature of the production system

The research established that 57% of the pastoral rangeland users were capable and ***willing to pay*** a mean fee of UGX 19,000 annually per square mile as rent for using rangelands if they were rehabilitated and contain adequate water and pasture. There were pastoralists who were already renting land at UGX 58,000. Analysis of the benefits arising from optimal management and open access systems of using the rangelands showed that the welfare of all people in the community was addressed in the optimal management system. It showed that open access system was monopolistic; costly to the society and not sustainable. The total ***economic benefits*** and expected returns from ***improved rangelands*** were UGX 42.7 billion and UGX 24.4 billion respectively. Therefore rehabilitation of the rangelands was justified as a viable venture.

The findings conclude that a resilient policy should take care of the institutional, economic, cultural and social interests of the local community in addition to the ecology in order to achieve a cost effective and sustainable management of the natural resource.

CHAPTER ONE

INTRODUCTION

1.0 Background

1.1 Concepts of Rangelands and Use

Rangelands provide the biggest bulk and least costly feed resources to domestic and wildlife ungulates in arid and semi-arid parts of the world. Rangelands are generalized as wild grasslands in which herbages are not artificially planted. The ecological features are characterized by high temperatures, low and high variables rainfall regimes, low vegetation cover density and fragile soil Kisamba-Mugerwa (un published, 2001), and are found in several parts of the world.

Rangelands are renewable and often trans-boundary natural endowments that are degenerating; and sustainable use and management of these natural resources is challenging because the users rarely appreciate the magnitude and scope of their usefulness, values, and risk associated with abuse of these resources. The values of rangelands resources range from providing primary materials for feed and food, shelter and medicines, "linking humanity to the sun and eventually to God" Sabiiti (2004) to indirect eco-services notably stabilization of micro climate, providing water catchments for local agriculture farmers and environmental amenities such as carbon sequestration, biodiversity and recreational facilities.

As an item among transboundary resources, the abuse and degeneration of rangelands has great impact on humanity and quality of life. Hence the United Nations recognizes that conservation and sustainable utilization of rangelands is a priority component in the concept of sustainable development (UN, 1987; Common Wealth of Australia, 1992). In this context natural, resources including rangelands are forms of capital, which, if depleted must either be replenished or substituted for countries to expand asset bases and increase dividend in the form of economic growth (Wetzman, 1976; Hartwick,1977; Dasgupta and Heal, 1979).

In Uganda, rangelands are largely found in the “cattle corridor” which geographically extends diagonally from the South West to the North East direction of the country. They largely cover the eastern and western regions of the country, estimated to be about 43% of the surface area of the country.

The rangelands of the cattle corridor support 56% and 60% of the total cattle and goat keeping households respectively, (Table 1); who own 64% and 65% of the national cattle and goat populations respectively (Table). Livestock production contributes 1.5% of the Gross Domestic Product (GDP) and it accounts for 1.6% of the county’s total exports where $ 18 million and $ 1.5 million were exports from Hides & skins and live animals respectively (Uganda Bureau of Statistics, 2008).

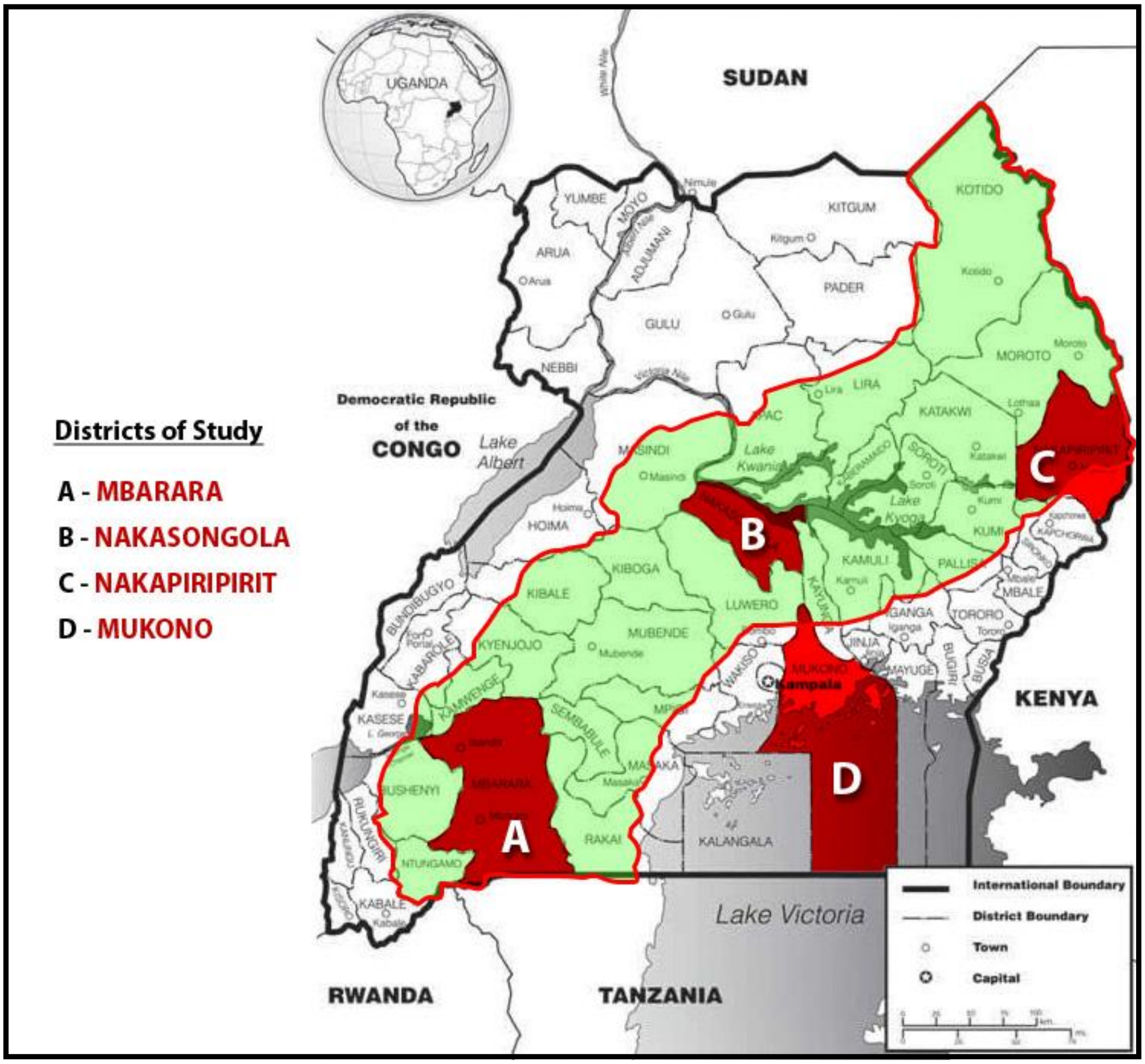


Figure 1: Map of the cattle Corridor of Uganda
Source: Livestock Routes, MAAIF (2009)

Table 1: Number households (HH) keeping Cattle and Goats in the Cattle Corridor

Region	HH keeping indigenous Cattle	HH keeping Exotic/crossbreed	Total No of HH keeping cattle	Total No of HH keeping goats
Eastern	416,449	53,981	470,430	531,111
Western	175,348	91,185	266,533	575,750
Cattle corridor	**591,757**	**145,166**	**736,963**	**1,106,861**
Uganda	**1,105,636**	**205,432**	**1,311,068**	**1,832,305**

Source: UBOS Agricultural Module 2005/06

Table 2: Population of herbivorous livestock in the cattle Corridor

Region	Cattle population	Goats population	Sheep population	Pigs population
Eastern	2,488,470	2,599,980	319,370	699,680
Karamoja	2,253,960	2,025,300	1,685,500	58,360
Western	2,548,620	3,432,240	567,390	778,350
Cattle corridor	**7,291,050**	**8,057,520**	**2,572,260**	**1,536,390**
Uganda	**11,408,750**	**12,449670**	**3,410,370**	**3,184,310**

Source: *National livestock census 2009*

1.2 Situation Analysis

The cattle corridor is composed of largely dry lands, covered by sparse vegetation and experience low and unreliable rainfall, Olson *et al* (2004). Kisamba-Mugerwa, (2006) identified a number of land tenure systems in the cattle corridor. In the central part of Uganda Nakasongola, absentee landlords own and rent some rangelands to livestock keepers. Communal ownership and open access is common in northeastern part of Uganda (Ministry of Agriculture, Animal Industry and Fisheries, 2004); while in the South-western Uganda (Mbarara, Ntungamo, Rakai, Sembabule and Bundibugyo) individual ownership of some rangelands as titled free/leasehold under the Public Lands Act of (1969). The predominant land use is ranching under the Land Act of 1998.

The pastoralists across the corridor have diverse cultures and, hence, perceptions of the rangelands (Kisamba-Mugerwa, 2001). Range of perceptions and values vary from cultures that claims exclusive ownership and access an infinite area of grazing land. The other extreme include cultures that neither claim nor respect ownership of land, but believe in open and unrestricted access to any land for grazing, including cropped areas. The differences in culture and awareness are compounded by the differences in land tenure systems. The interactions between culture, tenure and access present the institutions involved in development, management and protection of the resources with daunting challenges to address.

Communal ownership and open access of rangelands for grazing, without commensurate responsibility for protection and conservation for ecosystem health has led to overgrazing and de-vegetation. The problem is cited as serious in some parts of Mbarara District, the and the whole of Nakasongola district and Karamoja region. It has resulted into soil compaction; erosion; emergence of low-value grass species and vegetation, some of with have attained invasive status (Kabanyoro, 2002); and desertification particularly in Karamoja and Nakasongola districts including Kakuto County in Rakai district NEMA (2001). The overall outcomes are declines in carrying capacity of the land and subsequently low productivity. As a result, the pastoralists are constantly on the move in search of pastures and water. Migrant behavior precipitate conflicts between cultures and institutions that differ on perceptions of ownership, access-for-grazing rights; and responsibility for protection and conservation for posterity/environmental activism (MAAIF, 2004).

Government has endeavored to put in place policies and institutions to address constraints to responsible use of rangelands. These include: gazetting of land as game reserves and game parks; the Cattle Grazing Act of (1964), construction of water points under Livestock Services Project implemented in the 1990s, creation of Ministry of Environment (2006), the National Environment Management Authority, (1995) and Uganda is a signatory to the United Nations Convention to Combat Desertification (UNCCD). Other programs are the management of natural resources and environment protection under the Plan for modernization of Agriculture, PMA (2000), wetlands policy and currently pasture and rangeland development under the National Livestock Productivity Improvement Project, being implemented to benefit livestock owners, mainly in the cattle corridor.

Upto the end of 20th century efforts of government had failed generated solutions to soil erosion, and degradation of environment including rangelands (Kamanyire, 2000). MAAIF has therefore begun on the formulation of the Rangeland Policy. A number of studies have also been done aimed at finding solutions and appropriate policies for improving and protecting these rangelands but many have been found to lack comprehensive information. Kyagaba (2004) noted that few comprehensive studies have documented indigenous knowledge in rangeland management in Uganda.

One of the major shortcomings is that there is no systematic policy under which a comprehensively coordinated program is developed to integrate the pastoralists in the management of natural resource conservation and development schemes managed by the state (Kisamba-Mugerwa, 2006). Lack of community ownership provides the disincentive to identify with; and the justification for the lack of sensitivity to vandalism of infrastructure established for rangeland improvement programs (MAAIF, 1995). Katherine (2004) cites a number of studies where violent conflicts over natural resources are common and some of which include clashes between wildlife conservation interests and rural livelihoods as well as conflicts where local people have been displaced by commercial investments.

1.3 Problem Statement

The carrying capacity of the rangelands in the cattle corridor in Uganda is declining because of overgrazing. Efforts of government, to date, has failed to address the problem of overgrazing because of limited policy incentives to attract and sustain public and private investments for responsible utilization of rangelands while protecting and conserving the natural resource environment. There are information gaps on the factors/elements that attract willingness from the public and private sector to carry out investments in rangeland improvement.

1.4 Justification

For a long time, several policies and programs have been put in place to protect the rangelands from degradation and promote and sustainable management of the resource in Uganda but have not been systematic and effective, Kisamba-Mugerwa (2006). Stanford (1993) also analyzed that at micro and macro level, development interventions in rangeland areas in Africa have failed to generate higher levels of productivity to improve the welfare of local communities or protect rangelands from degradation. One of the contributing factors to the failures of the programs is lack of comprehensive data on all aspects of rangeland dynamics as well as all the players in the use of the natural resource, Kyagaba (2004). Deterioration of rangelands has a negative impact on livestock production and subsequently on the welfare and livelihoods of the people who depend on livestock in addition to the environment.

This research provides more data and endeavors to establish any gaps in various studies so far done so that any facts affecting the sustainable use and management of the rangelands are documented to enable the design of design appropriate strategies, programs and policies. The information will also be vital to the implementation of the ongoing programs.

1.5 Objectives of the Research

To provide comprehensive information on the socio-economic and ecological dynamics of rangelands for a robust policy that promotes a sustainable and optimal management of rangelands in Uganda. The specific objectives are:

1.5.1 To estimate the willingness to pay (WTP) and factors that influence the likelihood of WTP responses.

1.5.2 To estimate the Total Economic and Social and Environmental Benefits accruing from investments in improved rangelands,

1.5.3 To estimate the likely dynamic benefits shared by the livestock and rangeland owners as well as the community, arising from adopting optimal and open access use of the rangeland.

1.6.0 Hypothesis

1.6.1 Livestock keepers are not willingness to pay any rental fee for using well managed and improved rangelands.

1.6.2 There is no difference in benefits accruing to the society arising from using rangelands under either optimal management or open access use systems.

CHAPTER TWO

LITERATURE REVIEW

Literature provides a number of studies on management of rangelands but most of them are centered on ecological dynamics, with little emphasis on the politics and needs of various interest groups who are key stakeholders of the rangeland resources (Kyagaba, 2004). Katherine (2004), recognizes that there is need for researchers to combine awareness of political economy and political ecology, environmental discourse and narrative, not only with a natural sciences based understanding, but also with an understanding informed by local perspectives on environmental processes and causes of change.

Umrani (1998) observed that, as a policy alternative, government can influence stakeholders in the arid rangelands through direct taxation in order to provide good services. However, there was no information on the ability and willingness to accept the program. Nkonya *et al* (2004) cited studies which indicated that most literature does not relate natural resource management decisions to the livelihood strategies of households and with little information on the impacts of community.

2.1 Effects of Mismanagement

A number of studies have documented the effects of overgrazing in the rangelands. Chesham et al (2002) cites the effect of overgrazing in Tanzania as mainly due to open access system and large herds of cattle arising from unwillingness among livestock owners to de-stock. The effect is the replacement of high value perennial grasses with unpalatable weeds which has also been observed in Zimbabwe and Malawi. Emergence of poor pastures with species such as C*ymbopogon afronadas, Solanum incunum,* and shrubs like *Lantana camara* and *Acacia species* has been documented due to overgrazing in Uganda, Mwebaze (1999).

The replacement of the periodic grasses by weeds and other unpalatable species does not only lower productivity but also contribute to a range of external costs and through changes in water patterns (Randall et al, 2004). Sserunkuuma et al (1998) observed that open access use of rangelands causes over consumption of pastures which implies that they “mine” the natural resource at higher rates than is socially acceptable, thus, imposing a temporal externality to the society. This implies that the social, economic and ecological merits and demerits of cultural practices of the rangeland users needs to be quantified in economic terms order to provide authoritative premises for informed policy decisions on mitigation measures that enhances benefits to society.

2.2 Managerial Practices

Rangeland management practices have been known to improve livestock productivity and also protect the environmental status. Using a bio-economic model that determined economic returns, sustainability factors and impacts of policy on sustainability factors of grazing management technologies, the Australian experience (Randall et al, 2004) showed that there are a number of options that can be used for sustainable rangeland management. These include among others manipulating stocking rates, fertilizer inputs, rotational grazing, use of weed herbicides and replanting to hold water tables. Maximizing the available forage in the rangeland can be achieved through management of the stocking rate by manipulating the herd structure in tandem with the climatic seasons (Garoian et al, 1990). Sserunkuuma *et al* (1998) observed that the culture of discriminate sale of stock depending on sex and that of wealth storage into big herds, by the pastoralist, undermines the policy. They also used a bio-economic herd model and simulated it for calculating the carrying capacity (stocking rate) of the rangelands as management tool. Rangelands, especially in areas where communal use is practiced, are regarded as public goods meaning that no individual is willing to invest in the management of the resource.

Phil Franks *et al*, (2004), in their program document for the management of Kashyoha – Kitomi forest on the Lake Albert, Uganda, suggested that for sound environmental management, external stakeholders should pay for the services either through direct payment mechanisms or fiscal incentives provided through taxation and subsidy mechanisms, and negotiating mutually beneficial trades as is the standard practice in Western countries. They cited many examples that showed that justified involvement rural communities in controlling the natural resources within their environment, and promoting more equitable sharing of the costs and benefits related to the management of these resources are prerequisites for effective conservation of natural forests in poor countries. However success depended on willingness of resource users to pay (WTP).

2.3 Incentive to Investment in Natural Resource Improvement Programs

Benefits and willingness to pay for using a natural resource are incentives that attract public and private investment in natural resource improvement programs. Determination of benefits and willingness to pay helps authorities to design appropriate policies with investment potential of providing sustainable goods and services to the community. Pearce et al (1990) underscores the concept of benefit and willingness to pay, and observe that the benefit measure is established when individuals are presented with choices of goods and services.

Preferences will be manifested as individuals' willingness to pay (WTP) for the good or services. The total willingness to pay for the society is the aggregate WTP for each individual and is a measure of the total economic benefit of the project. However, there are differences in people's ability and WTP due to various factors, hence the market price will just be the total measure of the benefit from the good or service less the consumer surplus, which is the excess benefit for those whose ability to pay is higher, thus: *Gross WTP = market price + consumer surplus.*

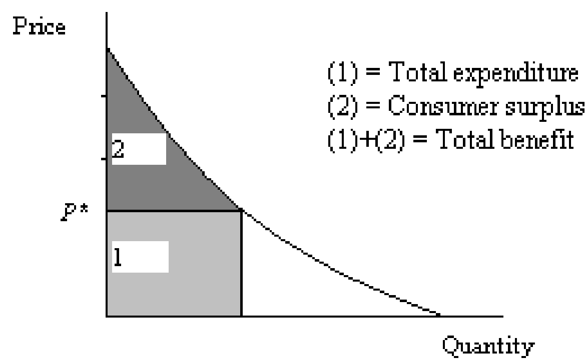


Figure 2: A demand curve for an environment good (Pearce et al, 1990)

The idea behind sustainable use of natural resources is for the society to have both benefits today (static benefits) and also in the future. Open access is equivalent to maximizing only static benefits while dynamic optimization is equivalent to maximizing dynamic benefits. The perception of future benefits is based on attaching price or user cost on the resource so that it should have a bequest or endowment value, Hertziler (2005) and it is expressed as: *Static Benefits + Total User Costs = Dynamic Benefits.*

However the prices of natural resources are never known because they are not traded in the market, Hertziler (2005) explains the theoretical scenario with two graphs bellow.

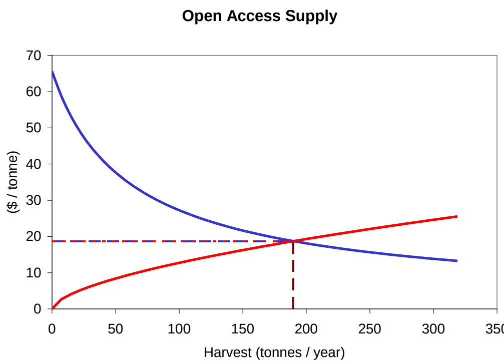


Figure 3: Source, (CEEPA, 2005)

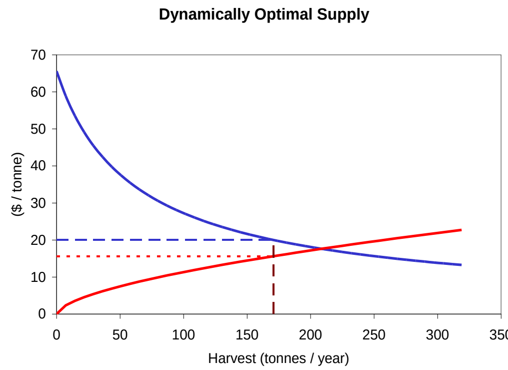


Figure 4: Source, (CEEPA, 2005)

The intersection of demand and supply gives the optimal quantity and the market price. However, open access is a market failure with overexploitation of the biomass arising from excessive harvest. The market fails because the price which is the marginal user cost of biomass is missing. The marginal user cost is added to the marginal cost of effort to account for all of the costs of the natural resource. In the optimal management, harvest is less and the price of harvest exceeds the marginal cost of effort. This difference is the marginal user cost. In the open access scenario, degradation leads to nutrient deterioration which Clark (2001) argues that it plays a role similar to depreciation in a capital model, increasing the impact of the discount rate and reducing the desired capital stock (forage) level.

Establishment of likely benefits derived from open access and optimal management of the rangelands helps to explore the implications for designing policies and put institutions in place to manage them, Hertzler (2005). Benefits attract willingness to pay user fees for the rangelands which is an incentive for investment in the improvement and management of the resource.

Justification of investments in natural resource improvement depends on the nature and magnitudes to social economic benefits the investment brings to society and individual. Willingness to pay (WTP) has been used as a proxy indicator for the incentives accruing from social benefits. A number of studies have shown that social benefits provide the incentives for public and private investments natural resources management as public and private goods and services. Alemu-Mekonen (2000) found that peasants were willingness to pay for community woodlots that are financed, managed and used by the communities themselves in rural Ethiopia. In Kumasi town, Ghana the demand for improved sanitation provided the incentive for willing to pay for water provision to households (Whittington et al, 1993). The results helped to design a policy on provision of water and sewerage services to the town. McConnel et al (1989) used WTP to measure the value of improvements in water quality in Barbardos and Uraguay. Other studies are WTP for social forestry in Orissa, India, Köhlin (1997); WTP for services from trees on communal lands in Zimbabwe, Lynam et al (1994) and willingness to accept format for land use restriction associated with a newly established national park in Madagascar by Shyamsundar et al (1996).

Econometric methods combined with ecological methods are used to derive economic merits and demerits of rangeland improvements. Using Noy-Meir grazing model to calculate the present value of forage stock, hence, the opportunity cost of consuming forage presently by marginally increasing the livestock, Ray *et al* (1991) found that overstocking reduced the cumulative benefits from the rangelands. Rashid (2002) quantified and analyzed the ecological impact of depletion and economic benefits of woodlands and forests on the economy of the Republic of South Africa and his values were adopted into the Systems of

National Accounts and the NDP adjusted. From the available data and accounting for the differences in herd management systems In Uganda at the time, Emerton *et al* (1999) study revealed that the indigenous plant-based resources could have an annual value of some UGX 163 billion calculated in terms of their contribution to pasture, fodder and forage. Hertzler (2005) simulated the likely benefits derived from open access and optimal management of a capture fishery to explore the implications for designing institutions to manage them. This study provides data on social benefits used for motivation of decision makers develop policies for protection of natural resources.

Toxopeus (1992) developed a spatial and modeling system as a user friendly tool for decision makers, for example managers, planers and others involved in the sustainable management of the Amboseli Biosphere Reserve, a semi arid rangeland ecosystem used by the Masai pastoralists in Kenya. The model simulated changes in the rangeland in order to examine and evaluate the effects of certain management decisions or policies on the ecosystem functions before taking them into practice.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Methodology Approaches

Two approaches were used in this research. First, a field survey using contingent valuation method (CVM) and second, a simulation method was used.

3.1.1 Contingent Valuation Method

The CVM was used to estimate demand of the rangelands in terms of willingness to pay (WTP), total economic benefits of the rangelands, and expected revenue from improved rangelands as well as socio-economic factors that affect WTP responses. This is because for any program to be accepted, it must secure buy-ins from the society. McConnel *et al* (1989) observed that for development projects which will alter the quality of a resource or the environment, contingent valuation methods have special appeal because they enable the researchers to measure the benefits in cases where there are sources of secondary data or no observable behavior to exploit. The CVM used by Whittington *et al* (1993) was adopted. However, the major concern with the use of the contingent valuation method is the potential for biased answers. There are five potential biases associated with the WTP responses and they are:

3.1.1.1 *Strategic bias* where individuals may be tempted to understate their WTP for a public good in hope of a free ride or others may over state their WTP in order to ensure the provision of the good.

3.1.1.2 *Starting point bias* which arises from the type of biding game used to elicit a WTP from respondents. Open ended questions may give outliers that distort the overall analysis.

3.1.1.3 *Hypothetical bias* which arises from the fact that respondents may not have the incentive to give correct answers especially if they need time and thought.

3.1.1.4 *Information bias* where individuals may interpret the question wrongly

3.1.1.5 *Instrument bias* which arises if the respondent is hostile to the means of payment

3.1.2 Simulation Method

The simulation method was used to simulate the optimal management and open access systems and analyze the dynamic benefits that accrue to different groups in the society in order to address the specific objective 1.5.3. The idea behind this was to establish the merits and demerits of the two systems. This is because the policy makers would like to know how a proposed program benefits the institution and the society it serves. This research adopted the simulation method used by Hertzler (2005), in his study Tuna fishery management as both fish and pasture are renewable resources.

3.2 The Study Area

The research was carried out in four districts namely Mbarara, Nakasongola, Nakapiripirit, which were purposely selected from the cattle corridor, and Mukono district selected outside the corridor. The idea behind this selection was to capture the different cultures and perceptions of the people along the cattle corridor and those outside it, in respect of the use of rangelands. It was also selected because most of the cattle corridor is economically and environmentally important to Uganda.

3.3 The Models

3.3.1 *The Multivariate Logit Model*

A multivariate binary logit model (McConnel et al, 1989) was used to establish the factors affecting WTP responses because the responses are categorical and dichotomous in nature; and help policy makers to design a policy which attracts buy-ins from the society (Wabwire, 1993). WTP is a binary response of either yes or no and the outcome is a probability which is expressed as Prob (Y = 1) when answer is yes and as Prob (Y = 0) otherwise. The WTP variable is dependent on other variables of the respondent such as sex, level of education and income. Where the response variable is dichotomous, taking 0-1 values, one of the widely used models is the logistic model:

(1) $$\text{Prob } (Y=1) = \frac{e^{\beta X}}{1+e^{\beta X}} = F(\beta x)$$

(2) $$L_{WTP} = \ln \frac{p_i}{1-p_i} = \beta_0 + \sum_{i=1}^{9} \beta_i X_i$$

where L_{WTP} is the likelihood of willingness to pay and X_i is a vector of explanatory variables where:

X_1 = Sex of the respondent, X_2 = Respondents paying cash rent, X_3 = average number of years one has been at school; X_4 = number of cattle a respondent possesses; X_5 = Cattle keeping system; X_6 = Availability of water, X_7 = respondents already paying rent, X_8 = Type of housing, X_9= Having property rights.

3.3.2 *The Single-equation Model*

Based on Lumby, (2005), a model was constructed to estimate total demand and total economic benefits of the proposed project plus revenue expected from charging the cattle keepers for using improved rangelands if a decision was made to rehabilitate them at a cost recovery basis. The assumption was that the respondents are willing to pay an amount and the amount varies with each respondent across the total population in the study area.

(3) $M_f = \dfrac{\sum F_i}{p}; \qquad F_i \geq 0,\ p > 0,\ i = 1,2....p.$

where M_f is the mean fee that the respondents are willing to pay, F_i is the fee given by each respondent and p is the number of respondents.

(4) $\boldsymbol{P} = \sum p$ where P is the total households with indigenous cattle in the study area.

(5) $E_b = \boldsymbol{P} * \dfrac{\sum F_i}{p}$, where E_b is the estimated total economic value of the project. It is also the estimated demand of the improved rangelands.

(6) $R_v = (\dfrac{p_f}{P}) * \boldsymbol{P} * M_f$ where R_v is the expected total revenue from the project and p_f is the number of respondents willing to pay a fee more than zero.

3.3.3 *Dynamic Simulation Model*

The dynamic simulation model was used because both static and dynamic benefits were simulated using future data which can only be abstract. The model used by Hertzler (2005) to study fishery management, was adopted and modified it to simulate the systems used in the rangelands and analyze the benefits accruing to the different groups in both scenarios. It was assumed that the pasture (grass) is a good with a price which varies across the entire rangeland and that it must be maximized over a time horizon of 25 years. The dynamic benefits are calculated from the Hamiltonian and first order conditions of the model.

(7) $$J(B_0) = \max \sum_{t=0}^{T} \left(\frac{1}{1+i}\right)^t \left[\int_0^H P_h(h)dh - P_e E(H_t, B_t)\right]$$

Subject to:

B_{t+1} - B_t = [f G (B_t)] – D [M (B_t)] - H_t

B_0 = $\bar{B}$

Where: J = net present value of benefits; P_h = price of the harvest; P_e = price of effort to produce grass; M = mortality of grass; $B_{t,}$ = biomass (total quantity of grass) at time, t; T = time horizon; i = social discount rate; E_t = effort to produce grass from biomass; H_t = amount of grass consumed or harvested; B_0 = initial biomass (total grass cover) before use of pasture; G = growth; f =land fertility; D = degradation of the pasture.

(8) $\left[\int_0^H P_h(h)dh\right]$ = the Total Benefits;

(9) $[P_e E(Ht, B_t)]$ = the total cost of effort of producing harvest

(10) $\left[\int_0^H P_h(h)dh - P_e E(H_t, B_t)\right]$ = the annual (periodic) net benefits.

(11) $H(E_t, B_t) = cE_t^{1/a} B_t^b c$ where c is harvest coefficient and $1/a$ & b are elasticities,

(12) $\frac{H_t}{E_t} = cB_t$ = “Harvest per unit Effort” and represents the efficiency of harvesting,

(13) G (B_t) = $f g B_t^{\mu} e^{-\theta B_t}$ is the growth function of the pasture,

(14) M (B_t) = $mB_t^{\nu} e^{\varphi B_t}$ is the mortality function,

(15) D [M (B_t)] = $mB_t^{d\nu} e^{\varphi B_t}$ is the degradation function and increases mortality rate where; g = the intrinsic growth rate; f =fertility level of the land; μ and θ are environmental

interactions on the growth rate; m = intrinsic mortality rate; ν and φ are environmental interactions on the mortality rate while *d* = level of degradation; μ = 1 and ν = 1 and the minimum viable range biomass is a stock of zero. Growth rate equals mortality at the carrying capacity of the environment and at the minimum viable population while the marginal growth rate equals marginal mortality at the rangeland biomass that gives the maximum sustainable yield.

The price in the demand curve is expressed as a non-linear iso-elastic curve as:

(16) $H = ap_h^{-b}$ where parameter *b* is the elasticity of demand.

However, for food and other basic needs, the demand is usually inelastic and *b* is usually less than 1,

(17) $p_h = \left(\frac{1}{a}H\right)^{-\frac{1}{b}} = \alpha H^{-\beta}$ where β is the flexibility and equal to 1/*b* while α = 1/a.

To compute Total Benefits which are expressed as the Total Willingness to Pay (*TWP*) in the society, the price function is integrated because TWP is a reflection of the aggregate demand. However, whenever flexibility, β is greater than 1, demand becomes inelastic and the price curve does not intercept the y-axis due to evaluating the integral at zero to become infinity. Hence, a positive quantity, γ, is added to the harvest to rectify the situation and the price is then expressed as:

(18) $\left(P_h = \alpha(H+\gamma)^{-\beta}\right)$

Consequently, integration of price in the equation (1) gives the TWP as equation (19).

(19) $$TWP=\int_0^H \alpha(H+\gamma)^{-\beta}\,dh=\tfrac{\alpha}{1-\beta}(H+\gamma)^{1-\beta}\Big|_0^H=\begin{cases}\tfrac{\alpha}{1-\beta}(H+\gamma)^{1-\beta}-\tfrac{\alpha}{1-\beta}\gamma^{1-\beta} & \beta\neq 1\\ \alpha\ln(H+\gamma)-\alpha\ln\gamma^{1-\beta} & \beta=1\end{cases}$$

The Net Present Benefit Value Model is then expressed as:

(20) $$J(B_0)=\max_{H_t}\sum_{t=0}^{\infty}\left(\tfrac{1}{1+i}\right)^t\left[\tfrac{\alpha}{1-\beta}(H_t+\gamma)^{1-\beta}-\tfrac{\alpha}{1-\beta}\gamma^{1-\beta}-p_e\left(\frac{H_t}{cB_t^b}\right)^a\right]$$

$$\text{subject to:}$$

$$B_0=\overline{B}$$

$$B_{t+1}-B_t=\left[fgB_t^{\mu}e^{-\theta B_t}-mB_t^{d\nu}e^{\varphi B_t}\right]-H_t \qquad t=0,\ldots,\infty$$

The Hamiltonian function for the model is then expressed as:

(21) $$\Pi_t=\left(\frac{1}{1+i}\right)^t\left[\frac{\alpha}{1-\beta}(H_t+\gamma)^{1-\beta}-\frac{\alpha}{1-\beta}\gamma^{1-\beta}-P_e\left(\frac{H_t}{cB_t^b}\right)^a\right]+\lambda_{t+1}\left[fgB_t^{\mu}e^{-\theta B_t}-mB_t^{d\nu}e^{\varphi B_t}-H_t\right]$$

The three dynamic optimization first-order conditions (*22*), (*23*) *and* (*24*):

(22) $$\frac{\partial\Pi}{\partial H_t}=\left(\frac{1}{1+i}\right)^t\left[\alpha(H_t+\gamma)^{-\beta}-\frac{\alpha}{1-\beta}\gamma^{1-\beta}-P_e a\frac{H_t^{a-1}}{\left(cB_t^b\right)^a}\right]-\lambda_{t+1}=0$$

(23) $$\frac{\partial\Pi}{\partial\lambda_{t+1}}=B_{t+1}-B_t=\left[fgB_t^{\mu}e^{-\theta B_t}-mB_t^{d\nu}e^{\varphi B_t}-H_t\right]=0$$

(24) $$-\frac{\partial\Pi}{\partial B_t}=\lambda_{t+1}-\lambda_t=\left(\frac{1}{1+i}\right)^t\left[P_e ab\left(\frac{H_t}{c}\right)^a+B_t^{-ab-1}\right]-\lambda_{t+1}\left[fge^{-\theta B_t}\left(\mu B_t^{\mu-1}-\theta B_t^{\mu}\right)-me^{\varphi B_t}\left(d\nu B_t^{(d\nu)-1}+\varphi B_t^{\nu}\right)\right]$$

$= 0$

(25) $[\lambda_{t+1}]$ = the marginal user cost (MUC),

(26) $[\lambda_{t+1}-\lambda_t]$ = the terminal marginal user cost (TMUC),

(27) $[\lambda_{t+1}H_t]$ = the total rent (TR),

(28) $\left[fgB_t^{\mu}e^{-\theta B_t}-mB_t^{d\nu}e^{\varphi B_t}-H_t\right]$ = the quantity of biomass used up.

(29) $\lambda_{t+1}\left[fgB_t^{\mu}e^{-\theta B_t}-mB_t^{d\nu}e^{\varphi B_t}-H_t\right]$ = the total user cost TUC.

(30) $\frac{\partial\Pi}{\partial H_t}=\left(\frac{1}{1+i}\right)^t\left[\alpha(H_t+\gamma)^{-\beta}-\frac{\alpha}{1-\beta}\gamma^{1-\beta}-P_e a\frac{H_t^{a-1}}{\left(cB_t^b\right)^a}\right]=0$ = open access with no MUC.

Open access maximizes only profit in each time period and the users will get only static benefits, hence the optimization equation has no price.

3.3.3.1 Model Assumptions

The assumptions of the model are as follows: First, the optimal management is construed to mean a combination of good managerial practices such as, control of stocking rate, use of fertilizers to improve pasture and utilization of over grown pastures as hay and silage during dry seasons.

Second, the amount of grass consumed by the livestock is the harvest and owners of the livestock wish to have grass from one time period to another, hence the harvest constitutes the benefits livestock owners get from the rangelands from one time period to another; where each time period is one year and the time horizon is 25 years, starting with year zero.

Third, a price is tagged on the harvest so that it can have value, hence the net present value (NPV) is maximized by choosing an amount of harvest to be consumed in each time period subject to the initial amount of grass on the rangeland and the value is measured by demand reflected by the willingness to pay (WTP) by the livestock owner for using the rangeland.

Fourth, the price of harvest varies across the entire rangeland; hence, integration of the price gives the total benefit from the entire rangeland and the total willingness to pay of the whole society. The Net Benefit (NB) in a given time period is total benefit less the Total Effort Cost (TEC).

3.3.3.2 Interpreting the Model

The marginal user cost (MUC) is the price per unit change in harvest volume and the terminal marginal user (TMUC) cost is the Marginal Bequest value or the MUC at the end of the time horizon. The quantity of biomass (QB) used up is the change in quantity from the initial amount of grass to that at the end of the time period and it is equal to the balance of grass that remains from that due to growth after natural death, degradation and consumed (Harvest). The MUC multiplied by the QB equals to the TUC while the MUC multiplied by the quantity harvested/consumed equals to TR. The total of the static benefits and the TUC is the dynamic benefits (DB). The price of harvest (POH), when multiplied by harvest and then subtract from TWTP gives the consumer surplus, (CS) while the marginal effort cost (MEC) multiplied by harvest or total revenue minus total effort cost (TEC) gives the producers surplus (PS). The TWTP minus the TEC gives the net benefits (NB).

3.4 Data and Data Sources

Primary data was collected from the field survey to determine the willingness to pay, the economic benefit of rehabilitation of the rangelands and the estimated revenue of the project while secondary and abstract data was used to simulate the management systems and the dynamic benefits accruing from each system.

The survey was carried out by the researcher and an assistant. Prior to the excise they got a brief training from an expert form UBOS on sampling and community interviewing techniques. The sampling was done by, first, clustering the districts of Uganda into categories of cattle corridor and otherwise. The districts in the cattle corridor were again clustered into three regions, Eastern, Central and Western in order to capture the different cultural and social differences. The districts from each region of the cattle corridor as well as those outside the corridor were written on pieces of paper and put in different boxes. One district was then selected randomly by picking one piece of paper from each box after shaking it where Mbarara, Nakasongola and Nakapiripirt were the three districts picked from the cattle corridor while Mukono district was picked outside the cattle corridor. Using the same system, two sub-counties were randomly picked from a list of sub counties in a district. In Mbarara district, Ibanda and Kanyaryeru sub counties were selected; in Mukono district Kasawo and Nabbale , in Nakapiripirit district Amudat and Namalu, while in Nakasongola district Kakooge and Nabitoma subcounties were selected. From each sub-county, 30 house-holds from which one respondent per house-hold was interviewed were randomly selected from a list of house-holds available at the sub-county. Hence, a total of 240 households were selected from the four districts whereby 60 were picked from each.

Prior to the day of administering the questionnaires, a meeting with a local leader was arranged to sensitize them on the program. The local leader was then requested to mobilize respondents from the house-holds selected and informed them of the nature of the program (rangeland improvement), the conditions under which the program would be implemented and the possible benefits to be derived from the proposed arrangements. The respondents were showed photographs and pictures of well-managed pastures. The following day the respondents were mobilized and handed questionnaires. Those who were able to read and write were allowed to fill in the questionnaires while for those who did not know how to write and read were availed volunteers to read and write for them. However the volunteers were asked not to influence the respondents' answers.

The survey questionnaire had three parts: The first part consisted of a hypothetical description of the terms under which the services will be offered to the respondent, including the photographs of improved rangelands in which there is enough grass, legumes, water, access to fodder and preserved grass such as hay and silage in dry seasons. A combination of "YES/NO" questions and a direct open ended question to elicit maximum and minimum WTP was asked (iterative bidding procedure). Part one had two sets of questionnaires, but equal in number, given to different respondents whereby a respondent answered a questionnaire from only one set.

In the first set the respondents were asked if they were willing to pay a minimum and then a higher figure, while in the second set the respondents were asked the maximum and then a minimum figure. The second part also contained questions about the respondent's demographic characteristics of the household. The final part had questions about the perceptions of the rangelands and the socio-economic characteristics of the respondent.
The inclusion of photographs and the iterative bidding procedure was used to mitigate the problems of information and starting point biases. Strategic and instrument biases were addressed by informing respondents that everyone would be required to pay and either cash or in kind. The hypothetical bias was handled by good public relations.

3.5 Data Analysis

The primary data collected from the survey was analyzed by computer using STATA software to estimate the WTP and establish the factors that influence the likelihood of the WTP responses. The secondary data was used in the simulation model and was analyzed using Excel software where macros was used to iteratively calculate 25 equations each representing one time period in a 25 year time horizon and compute the optimal levels at the equilibrium state.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

Table 3 presents the overall findings from the survey across the study area in terms of frequencies and percentages. Out of the 240 respondents, 87% were male household heads while 37% were female household heads and the average number of years in school was seven. The number of respondents keeping cattle was 175; representing 73% of the households; and the average number of cattle per individual was 43. Eighty two (82%) of the cattle keepers were using traditional system while 18% had fenced farms. The cattle keepers who were already renting grazing land were 38%where 63% of them were paying in cash while the rest paying in kind. The percentage of respondents with property rights over the grazing land, represented by sole ownership (21%), family ownership (19%) and other privately owners but rented by the cattle keepers themselves (6%) grouped together was 46% while the rest was communal and government owned. Results also show that 37%, 38% and 25% of the respondents across the study area had permanent, semi permanent and temporary houses respectively. Respondents with enough water were 18% against 82% with inadequate water throughout the year. The source of water in the study area was 48% natural source, 28% self provided, 6% government provided and only 1% provided by Non Government Organizations. During scarcity of water and grass in dry season, 22% of the respondents sell off some livestock, 50% move to another area and 28% buy some feeds.

Table 3: Socioeconomic and demographic characteristics of respondents (All respondents = 240, cattle keepers only = 175)

	Response	Frequency	Percent
1.	***Willingness to Pay***		
	WTP responses (All Respondents)	129	54*
	Willing to pay Shs100,000 per sq mile, p.a	57	50*
	Willing to pay Shs50,000 per sq mile, p.a	31	57*
	Willing to pay Cash	70	56*
	Willing to pay in Kind	56	44*
	WTP (Cattle keepers only)	100	57
2.	***Cattle Ownership***		
	Respondents owning cattle	175	73
3.	***Sex of HH (Cattle keepers)***		
	Male	129	87
	Female	30	36
4.	***System of Cattle keeping***		
	Traditional cattle keeping	134	82
	Fenced Farms	30	18
5.	***Respondents paying for land***		
	Cattle keepers charged for using land	55	38
	Cattle keepers who pay in cash	33	63
	Cattle keepers who pay in kind	19	37
6.	***Land Tenure***		
	Self/own	35	21
	Community	78	47
	Family	32	19
	Government	11	7
	Private	10	6
7.	***Housing***		
	Permanent	62	37
	Semi permanent	64	38
	Temporary housing	43	25
8.	***Availability of Water & Source of Water***		
	Cattle keepers with enough water	30	18
	Cattle keepers without enough water	140	82
	Natural Source	83	48
	Self Source	48	28
	Government Source	11	6
	NGO Source	1	1
9.	***Adaptation to Dry Season***		
	Choice to sell animals	31	22
	Move to new area	70	50
	Buy feeds	40	28
	Willing to stay if Enough Water & Grass	106	96

Source: Field survey, * percentage based on all respondents (240)

4.1 Willingness to Pay

To address the first specific objective, all respondents were asked if they were willing to pay when the rangelands were rehabilitated for purposes of providing pasture and maintaining the environment. The results show that 54% of all respondents were willing to pay for maintenance of rangeland but it was 57% for only the cattle keepers.

For the respondents who were willing to pay, 56% preferred to pay in cash as opposed to paying in kind. Bidding system was used to determine the minimum and a maximum amounts which the respondents were willing to pay. To that effect, 50 % were willing to pay 100,000 Uganda Shillings annually per square mile, but the percentage increased to 57% when the amount was reduced to 50,000 Uganda Shillings per square mile. For the respondents willing to pay less than 50,000 Uganda Shillings, the mean amount was 19,000 Uganda Shillings while for those who were already being charged for using the grazing land, the mean amount was 58,000 Uganda Shillings per square mile.

The results reveal that as a whole, the majority of the respondents across the study area were willing to pay for the improved rangelands which would provide water and grass for livestock as well as maintaining the environment. This implies that even respondents without cattle were aware of the importance of the rangelands. McConnel *et al* (1989) also used WTP in contingent valuation survey and were able to get positive results for environmental protection pegged on provision of sewer system in Barbados. In this research, findings also reveal that when the proposed rent was reduced from 100,000 to 50,000 Uganda Shillings the quantity demanded increased and the quantity demanded was even higher among cattle keepers. These phenomena agree very well with the economic theory of utility and demand whereby under normal circumstances, decreasing price causes increase in quantity demanded. This is also not surprising for the cattle keepers because they get direct benefits from the program. They consider the program as a source of inputs to their cattle keeping business whose average herd is 43 and it should be noted that meet pasture and water needs of cattle is one of the main reasons why pastoralists move from place to place in dry seasons.

WTP is a powerful tool used for assessing the perception and acceptability of a social service. Köhlin (1997) used WTP for provision of social forestry in Orissa, India. Lynam et al (1994) used WTP for services from trees on communal lands in Zimbabwe; and Shyamsundar et al (1996) used willingness to accept format for land use restriction associated with a newly established national park in Madagascar. This phenomenon was also used in the feasibility study, in Mbarara district, for the Dry land Husbandry Project, Sabiiti et al (1994). They found that about 68% of the respondents supported the idea of cost-sharing in as far as water resource management is concerned. Against the foregoing observations, therefore, the hypothesis that pastoralists have no willingness to pay for using rehabilitated rangelands is rejected.

4.2 Socio-economic Factors

The percentage WTP was plotted against socioeconomic variables and a curve drawn and presented graphically by figure 5 below. It was observed that the proportion of people who had fenced farms had a bigger percentage of respondents with WTP compared to the proportion with traditional cattle keepers.

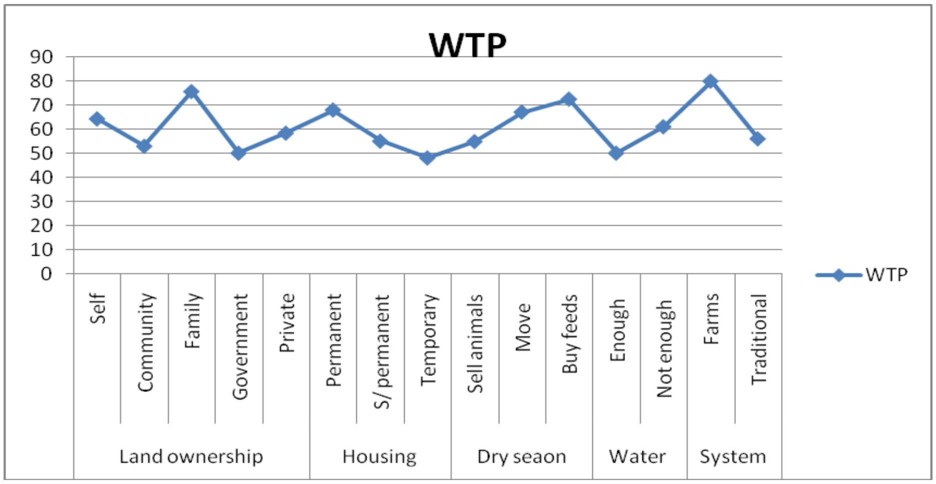


Figure 5: Influence of Socioeconomic Variables on WTP.

There were a bigger percentage of WTP responses among people using their own land, family and privately rented rangelands, on one hand, compared to those on community and government lands on the other hand. With housing, WTP percentage response was highest among the people owning permanent houses followed by semi permanent houses and lowest among those living in temporary houses. These results agree well with the phenomenon on property rights. The people on own, family and private land have control or rights on the land; therefore it is a matter of fact that this group will be willing to pay for the services as opposed to those using communal and government where they would prefer free riding. Renting is one of the ways in which a person obtains some rights on a property. This corroborates with the observations on the cattle keeping system and housing ownership. The respondents with fenced farms as well as permanent houses most likely had property rights over the grazing land. This phenomenon was also observed by Whittington et al (1993) where people who owned houses rather than renting had greater willingness to invest in improved sanitation services in their own property.

Availability of water was one of the variables which notably attracted more WTP responses. Eighteen (18%) percent of the respondents said that they had enough water and grass in most cases while 82% said they did not have enough and it was observed that there was higher WTP among the respondents who had inadequate water throughout the year compared to those with enough water. This is expected because the respondents were told that the project would provide water throughout the seasons. This relationship between water availability (and land ownership) vis-á-vis WTP was also observed with similar response in Mbarara district by Sabiiti et al (1994). Figure 8 illustrates the impact of the variables which are the socioeconomic factors on the willingness to pay responses.

Responses to inadequate water and grass during dry season reveal that highest WTP responses were observed among those who supplement their livestock with feeds, followed by those who move to new areas to look for grass and lastly among those who sell some of their animals to reduce on numbers. The findings reveal that pastoralists also provide supplement feed to their livestock while the rest do either control their stocks or relocate to another part of the rangeland. With these responses, a strategy could be designed to encourage and provide incentives to crop producers so that they collect, package and preserve post-harvest wastes such as potato vines, maize left over and any other wastes from other cereals into hay and sell to cattle keepers in dry areas. This valuable resource is usually wasted away by burning every season, yet if preserved people would sell the byproducts to the livestock keepers. This initiative would improve the welfare of crop farmers and also improve livestock production. Maize and rice bran are currently the commonest and probably the only byproducts being sold to piggery and dairy farmers. In the 1970's Mubuku irrigation scheme used to produce hay and supply it to government farms as a way of maximizing the excess pasture (MAAIF, 1972).

Results also reveal that some pastoralists sell off some livestock as a way of controlling the stock numbers during scarcity of grass and water and that they are willing to pay for the program that provides their needs. This further provides an opportunity to encourage traditional livestock keepers and pastoralists to move away from keeping livestock as a way of life and prestige to a profit oriented business could be designed. The livestock keepers could be encouraged to sell off some livestock as a way of scaling down the herd when it becomes so big and in dry seasons when feeding is a problem. The proceeds could be used to improve rangeland management or invest in other ventures for example small scale beef or milk processing plants or even buy land and establish farms and ranches. The pastoralists are capable of changing as observed in the present Bugiri district (personal experience as an extension officer, 1990s where two pastoralists were convinced to maintain few manageable herds, sold off some cattle and constructed buildings which house butcheries and dairy stores among other things.

Interestingly, the movement of respondents from one area to another is an adaptive mechanism in response to inadequate water and grass during the dry season. The research findings show that 96% of the people are willing to stay in one area if they had enough water and grass. This observation, therefore, serves to reject the hypothesis that moving from one place to another by the pastoralists is just a way of life. In the actual sense, it is an indigenous technology to cope with adverse circumstances. Kanyangareng (2007) also cites previous studies which revealed that pastoralism is not just a way of life but rather, a scientific practice, a rational and efficient low-intensity stock rearing production system suited to the fragile environment pastoralists live in. He adds that pastoralist is not a backward practice but rather a rational adaptive strategy (technology). Mwilawa et al,(2008) also found out that traditional methods have been used among the pastoral and agropastoral communities for many years to preserve pastures namely ‘Olopololi ⁄ Alalili’ for Maasai, ‘Ngitili’ for Sukuma and ‘Milaga’ for Gogo in Tanzania.

The WTP responses and rvations of the variables namely; system of cattle keeping, land renting, property rights, type of housing, availability of water and source of water were also disaggregated and tabulated per district and presented in table 4.

Table 4: Socio economic characteristics of responds (%) by District

		Mbarara (N=59)	Nakapiripirit (N=60)	Nakosongola (N=62)	Mukono (N=58)
1.	***Willingness to Pay***				
	WTP (Cattle keepers only)	57	46	58	66
2.	***System of cattle keeping***				
	Traditional	77	97	78	79
	Fenced farms	23	3	22	21
3.	***Respondents paying for land***				
	Cattle keepers charged for using land	51	4	50	30
4.	***Land Tenure***				
	Self/own grazing land	25	3	27	27
	Community grazing land	66	76	42	13
	Family grazing land	6	3	17	47
	Government grazing land	3	18	4	2
	Private grazing land	0	0	10	11
5.	***Property Rights on Land***				
	Combination (Self, Family & Private)	31	6	54	85
6.	***Housing***				
	Permanent House	31	12	15	78
	Semi-permanent house	42	43	37	11
	Temporary house	27	45	48	11
7.	***Availability of Water***				
	Cattle keepers/enough grass & water	8	3	14	42
8.	***Source of Water***				
	Natural	38	59	44	52
	Self/own	28	11	30	39
	Community	28	11	22	7
	Government	5	18	4	0
	NGO	0	0	0	2

Source: Field Survey

The overall WTP responses were 47%, 42%, 61% and 66% for the respective districts and also 57%, 46%, 58% and 66% for cattle keepers only. The observations reveal that there was a consistent trend in variations in the WTP responses vis á vis the other variables from district to district. For instance, a district with more people with property rights also had higher percentage of respondents with WTP than those without while the district with more permanent and or semi-permanent housing had more people with WTP responses than the portion with temporary houses. Nakapiripirit had the highest number of respondents keeping cattle traditionally and had the least number of cattle keepers willing to pay. In the same way, the district with a bigger portion of people without adequate water had more respondents with WTP and so on.

The percentage WTP responses and the socioeconomic characteristic variables and were all plotted against the districts and curves drawn to establish if there was a relation between the variables and WTP as presented in Figure 6.

%

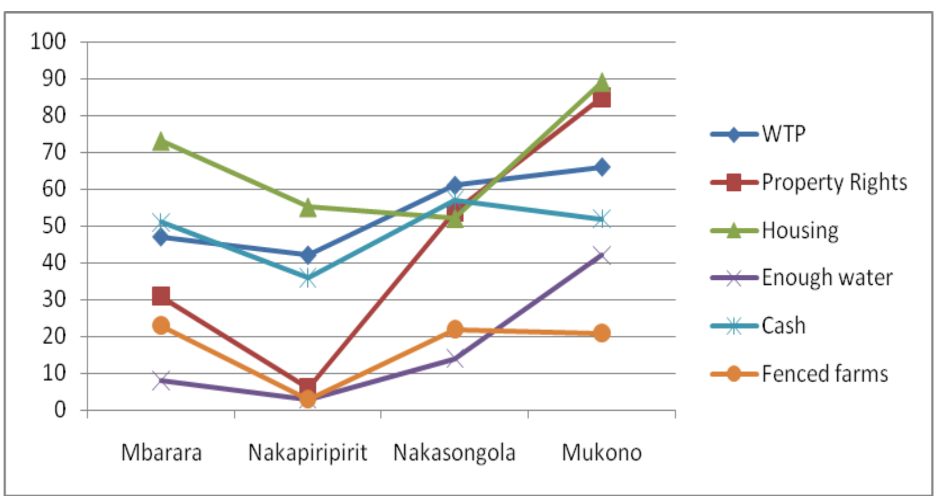


Figure 6*: Relationship between WTP and socioeconomic characteristic curves across the districts.*
Source: Research Study

The results reveal that the shapes of the curves of the variables are closely similar to that of WPT along the districts, showing that where the district had the greatest percentage of responses to a variable, the same district also had the greatest percentage of WTP responses. This confirms that the variables are some of the factors that have influence on the willingness to pay.

4.3 The Multivariate Logit model

A multivariate logit model was used to analyze further and more socio economic factors namely; sex of respondents, mode of payment, education, number of cattle, farming system, availability of water, being a tenant, type of housing and finally having property rights in order to determine their influence on the likelihood of willingness to pay for the services in the proposed project. This addresses the specific objective in 1.5.1. Table 5 presents the Odds Ratio (OR), standard deviation, *Z* and *P* values of the model.

Table 5: Likelihood estimates of the logit model for WTP (N=175 cattle keepers only)

Variables	Odds Ratio	Std Err	Z	P>|z|
Male Sex	4.159115	1.6462230	3.60	0.000
Preference to pay cash	1.947587	0.7012973	1.85	0.064
Level of education	1.084443	0.0459041	1.85	0.064
Number of cattle owned	1.009280	0.0045433	2.06	0.040
Fenced Farming	1.421982	0.6693981	2.00	0.045
Inadequate water	1.332484	0.6342164	2.01	0.044
Being a tenant	0.390141	0.1451372	-2.53	0.011
Semi &Permanent house	2.103452	0.9291248	1.68	0.092
Having property rights	1.041380	0.4066861	2.35	0.019

Log likelihood = -96.043466, ***No. of obs*** = 175, ***LR chi2* (*9*)** = 46.33, ***Prob* > *chi2*** = 0.0000, ***Pseudo R2*** =0.1943

Source: Field Survey data

The interpretation is that (OR-1)*100 is the percentage increase in the chances of willing to pay due to the influence of the variable. It was found that being male increases the chances of one willing to pay by 316% and very significant (p-value 0.000) while the chances of WTP for respondents increases by 94%, but not significant (p-value 0.064), if they were willing to pay cash other than in kind for using the land. The results also show that education which was represented by the number of years one stays in school increases the chances of WTP by only 8% and also not significant (p-value 0.064). The influence of male gender on the willingness to pay is not surprising because in these areas, the society is mainly dominated by males in which case house hold incomes and wealth matters are mainly controlled by the male gender. This was also observed by Sabiiti *et al* (1994) during their feasibility study for the dry land husbandry project. This implies that since the majority of cattle keeping is dominated by the male gender, the prospects of obtaining willingness to pay responses to the cost sharing rangeland management are high.

Education was found to be statistically not significant because, while education plays an important role in improving one's understanding and reasoning, however my understanding is that it does not necessarily affect the demand for basic needs. While water and grass are inputs for the cattle keeping business, water is also a direct human basic need and grass is an indirect basic need as it is used to feed cattle which are a source of food. Benefits from basic needs cut across the board. From theory (James, 1977), demand is to do with consumer choices which are influenced by changes in benefits and costs which are independent of education. Education was also found not to be significant in the CVM study of the household demand for the improved sanitation in Kumasi-Ghana, Whittington et al (1993).

However, Kisamba-Mugerwa (2006) findings revealed that educated household heads were more likely to invest in rangeland improvements and are less likely to report degradation of grazing lands as a problem. This is surprising, though, because educated people are expected to have a sense of reasoning to understand that degradation has a negative impact on productivity of the rangelands.

The number of cattle owned by a respondent was found to increase the likelihood of WTP by 1% (p-value 0.040) while owning a fenced farm increases the likelihood of WTP by 42% (p-value 0.045). The number of cattle owned affects the chances of one's WTP marginally but it is found to be statistically significant. This is clear because whether a person has two or twenty heads of cattle, both equally need water and grass for their livestock, so numbers may not necessarily matter but what is very import is possession of cattle which increases the demand. However, the findings of Kisamba-Mugerwa et al (2006), in Mbarara district, indicate that numbers are also very important in that households with more livestock were found to be more likely to invest in rangeland improvements. It is also noted that cattle keepers with fenced farms are more likely to pay, and this is because their farms are restricted to themselves and therefore not worried of free riders.

For the availability of water, it was found that if one had no adequate water for the cattle, the chances of willing to pay for improved rangelands increases by 33% and the influence is significant (p-value 0.044). It is not surprising that the likelihood of WTP for water among the respondents faced with inadequate water is high and significant because water was ranked second to schools when respondents were asked to put their needs in order of importance if the government was to provide them as presented in figure 7

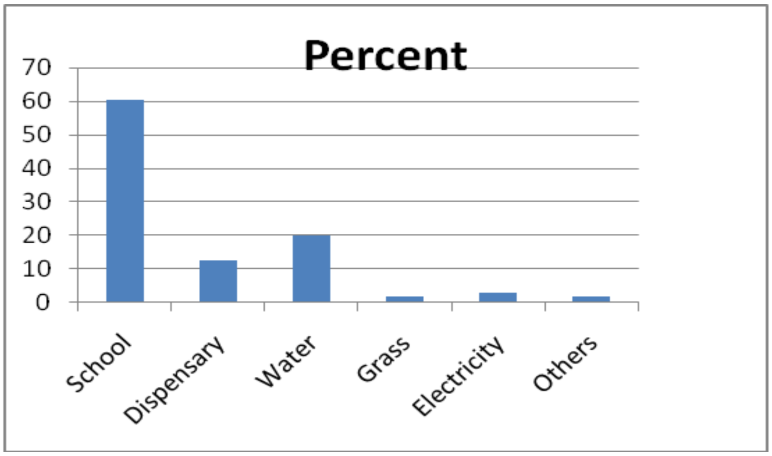


Figure 7: Ranking of Respondents' Needs

The findings validate the fact that water is one of the most important inputs for livestock production and also alludes to the conclusion that one of the reasons why the pastoralists move from place to place is because they are looking for water for their livestock and own consumption. This validates further the 97% responses obtained from the survey that the respondents would prefer to stay in one place if enough water and grass were provided in the grazing land. Kisamba Mugerwa et al (2006) also found out that improved access to water can have substantial positive impacts on pastoralists' investments in improved rangeland and livestock management. Interestingly, the findings reveal that the major sources of water in the rangelands were natural, self, community, government and NGOs. However, the majority of cattle keepers in the rangelands get water from natural sources while the government is the second last provider to the NGOs as presented in Figure 8

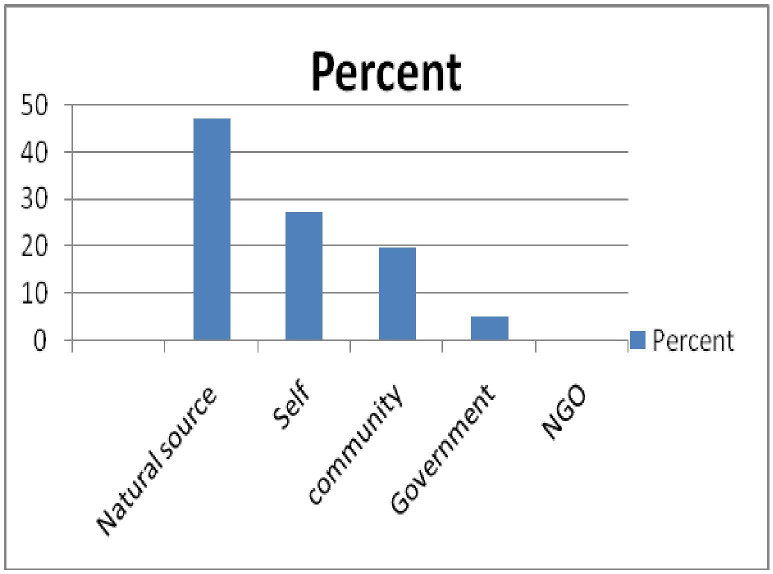


Figure 8: Source of Water in the Rangeland

This, therefore, means that there is need for the Government to invest more in provision of water in these areas so as to improve the welfare of the people and also increase livestock production. It is also very important that technologies for water harvesting and watershed management are developed, and irrigation be encouraged in order to maximize any water available.

The likelihood of WTP of the respondents who were already renting the land for grazing, however, decreases by 61% and the factor in statistically significant (p-value 0.011). This is perhaps due to the fact that the cattle keepers believe that it would be unfair for them to pay for the improvement of pastures on the land they are already renting as this may be tantamount to additional levy.

The chances of WTP for the respondent increases by 110% (p-value 0.092) if one had a permanent or semi permanent housing and also increases by 4% (p-value 0.019) when a respondent has property rights on the land. It was assumed that respondents using individually and family owned as well as other private land had property rights. The findings reveal that although housing may seem to increase the likelihood of WTP, however, it is not statistically significant. This is not surprising because the pastoralist by culture do not construct permanent houses for example the people in Karamoja live in Manyattas which are temporary huts. On the other hand, having property rights on the grazing land was found to increase the likelihood of WTP and statistically significant. This is consistent with the available literature and further validates the findings already observed in this study that people with control over the rangeland are more likely to contribute to a project that adds value to it. Respondents owning land are more willing to spend money on services without worrying about free riders. Kamanyire et al (2000) also identified land tenure as an important factor in natural resource and rangeland management, and policy in Uganda. The findings by Kisamba-Mugerwa et al (2006) also revealed that individualization and privatization of rangeland tenure in the southwestern part of Uganda have contributed to investments in rangeland management, including bush clearing, improving pastures and planting multipurpose trees.

4.4 Total Economic Benefit (TEB)and Expected Revenue (ER)

Total economic benefit and expected revenue from using improved rangelands were computed using 57% as the proportion of respondents (cattle keepers) willing to pay the average of 19,000 Uganda Shillings per square mile per annum as well as the average actual rent of 58,000 Uganda Shillings that was being paid at the time of the study. Computation was done using equations 4, 5 and 6 with the households figures from the UBOS agricultural module (2005/06) which show that the number of households keeping cattle was 736,963 in the cattle corridor and 1,311,068 in the country. Table 6 presents the results computed for the cattle corridor and the country.

Table 6: Total Economic Benefit and Expected Revenue (Cattle Keepers only)

Region	HH keeping cattle '000'	57% HH WTP '000'	TEB at WTP Fee '000'	TEB at Actual Fee '000'	ER at WTP Fee '000'	ER at Actual Fee '000'
Cattle corridor	737	420	14,002,297	42,743,854	7,981,309	24,363,997
Uganda	1,311	747	24,910,292	76,041,944	14,198,866	43,343,908

Source: Field Survey and UBOS (2005/6):

From the findings the estimated total economic benefit from the improved rangelands using the mean willingness to pay fee were 14.0 billion Uganda Shillings in the cattle corridor and 24.9 billion for all the cattle keeping households in the whole country. On the other hand, the total economic benefits using the actual rent were computed as 42.7 billion in the cattle corridor and 76.0 billion Uganda Shillings for the whole livestock supporting vegetation in the country. However, Emerton et al (1999) found that the total area with indigenous plant-based resources that contribute to pasture, fodder and forage was estimated at an annual value of USh 163.0 billion per annum.

The expected revenues computed using the mean willingness to pay value were computed as 8.0 billion Uganda Shillings in the cattle corridor and 14.2 billion Uganda Shillings from all cattle keeping households in the country. When the actual rent paid at the time was used, expected revenues were 24.4 billion and 43.3 billion Uganda Shillings for the cattle corridor and all the cattle keeping households in the country respectively.

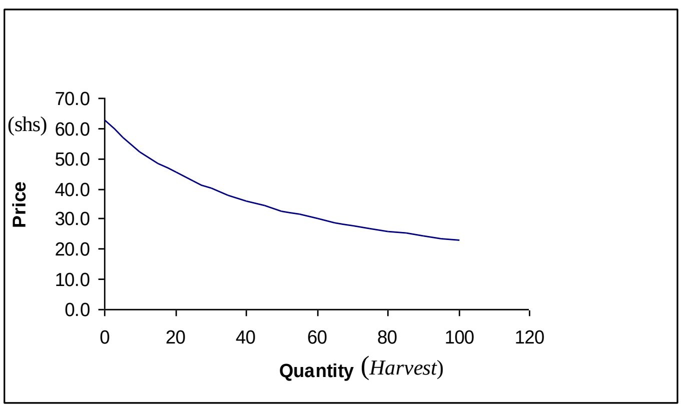
The research also reveals that the rent that was being paid by some respondents was about three times more than what they were willing to pay. This was not surprising because grass and water are essential and basic goods which tend to have inelastic demands, Khaukha (1992), Hertziler (2005). Willingness to pay is also often used as an estimate of indicative revenue expected from the services and as an indicator of the viability and total economic benefit of a project. McConnell *et al* (1989), Wittington *et al* (1993) and North *et al* (1993) analyzed WTP and estimated the mean WTP fees for some social services.(what did they find?).

The results further reveal that the expected returns and total economic values were substantial and moreover the amounts computed from the actual rent are even much higher. For example the expected revenue from the cattle keepers of the cattle corridor alone was Shs 8 billion and Shs 24.4 billion computed from the mean WTP and actual rent. The figure from the actual rent is very close to the 2007/08 outturn of Uganda's non tax revenue of 28.7billion Uganda Shillings, MoFPED (2007).

The total economic benefit and expected revenue are very important parameters to be considered when planning an investment. The former gives an indication to the investor, especially if it is government, whether the project is worthwhile to the national economy and on the other hand, the latter is used to estimate the returns expected from a planned new product. Using Hedonic Pricing method, North et al (1993) used the computed households' WTP to estimate the economic benefits that could result from improved water supply systems.

4.5 Dynamic Benefits

The simulation model was first calibrated using the price function (equation 4 of the model in the appendix A) and abstract demand parameters which were chosen so that a non-linear negative curve, widely used as a demand curve in market equilibrium models, is achieved as shown in figure 9. The hypothetical parameters used were 1200 for scale (α), 0.8 for price flexibility (β) and 40 as shift (γ). Toxopeus (1992) used abstract data combined with both spatial and temporal data in a spatial and modeling system in such a way that it is able to simulate the process going on in the ecosystem in space and in time.



Source: Field Survey

Figure 9: ***Calibrated Demand curve of simulation model***

The benchmark parameters used by Hertzler, (2005) in a fishery resource management model were adopted and used in this model as rangelands are also natural resources with similar life cycle. The Parameters are presented in table 10, below.

Table 7: Baseline Parameters

Parameters	Value	Parameters	Value
Scale	1,200.00000	Effort flexibility	1.60000
Price Flexibility	0.80000	Stock Elasticity	0.40000
Shift parameter	40.00000	Harvest Coefficient	0.15000
Growth intrinsic rate	0.50000	Mortality intrinsic rate	0.0402
Growth environment 1	1.00000	Mortality environment 1	1.00000
Growth environment 2	0.00001	Mortality environment 2	0.00251
Discount Rate of harvest	0.02000	Fertilizer rate	1.00000
Price of Effort to harvest	1.50000	Degradation Level	1.02000
Initial Biomass (BIOM)	900.00000		

Source: CEEPA (2005)

Table 8, below, presents a simulation of the optimal (OPT) and the open access (OA) situations and the impact of selected management variables namely; efficiency, fertility and degradation on the amount of social benefits. The variables were modeled in equations 9, 10 and 12 respectively and the benefits were automatically computed using the benchmark parameters and apportioned by a computer to different stakeholders in the optimal and open access systems.

Table 8: Dynamic Benefits in Optimal (OPT) and Open Accesses (OA)

Benefits	**Baseline**		**Fertility at 1.20**		**Degrad. At 1.22**		**Efficiency at 0.3**		**Discount rate 25%**	
	OPT	OA	OPT	OA	OPT	OA	OPT	OA	OPT	OA
TWTP	241,450	256,836	259,909	270,637	230,325	246,583	267,470	30,730	24,423	25,629
TEC	-73,511	-91,352	-82,869	-94,308	-68,886	-89,091	-36,449	-9,550	-7,742	-9,052
NB	**167,939**	**165,484**	**177,040**	**176,329**	**161,439**	**157,492**	**231,021**	**21,180**	**16,681**	**16,577**
CS	100,742	110,673	112,678	119,744	93,698	104,037	117,670	15,229	10,359	11,145
TR	23,090	0	14,641	0	26,409	0	91,482	0	1,677	0
PS	44,107	54,811	49,721	56,585	41,332	53,455	21,869	5,951	4,645	5,432

Source: Field Survey

Results shows that TECs subtracted from TWTP give the NBs in hypothetical units per annum (upa) and were apportioned to consumer surplus, total rent and producer surplus. In all simulations, dynamic benefit values are higher in optimal management than in the open access systems. Simulation of increased fertility predicts the benefits to increase from

167,939 upa and 165,484 upa to 177,040 upa and176, 329 upa respectively while with increased degradation, and the benefits reduce to 161,439 upa and 157,492 upa respectively. On the other hand, while increased efficiency greatly increases the benefits in the optimal management to 231,021upa but heavily reduces benefits to 21,180 upa in open access. Increased social welfare from 2% to 25% causes sharp decrease of benefits to 16,681 upa and 16,577 upa.

The whole essence of optimal management of the rangeland is to maximize the total willingness to pay (TWTP) minus the total effort costs (TEC) and apportion the net benefits to all parties in the society over an infinite period, thus on a sustainable basis. These are the livestock keepers (consumers), pastures owners (producers/owners of land) and the community (government and beneficiaries from the environment). Establishing dynamic benefits of a program is very important for policy makers because they have the obligation to look after the wellbeing of all stake holders in the community.

The simulation reveals that in the optimal management system, the net benefits are higher in the optimal management than in the open access. Furthermore, in the optimal management all the three categories in the community get benefits while in the open access system the rent is not realized. It was also revealed that in the open access, the demand, represented by the total willingness to pay as well as total effort cost are higher in the open access than in the optimal management system. This is not surprising because in the open access, there is no marginal user cost, so very many users scramble for the resources which then become scarce. This implies that they have to increase on the total effort cost to cope with the "survival for the fittest" situation which results into over consumption of the resource. Sserunkuuma et al (1998) observe that over consumption (open access use) is like "mining" the natural resource at higher than is socially optimal, thus, imposing a temporal externality to the society. So, society is better off with the optimal management and therefore voiding the hypothesis that there is no difference in benefits under either system.

In natural resource management, marginal user costs are very important. If not considered, then the total rent, which is the product of marginal user costs and the quantity of the resource harvested/consumed, will be zero. If the total rent is valuated, the recipient institution can use it to service the natural resource as well as to mitigate any externalities that result from the use of the resource (Hertziler, 2005).

4.6 Optimal Management Tools

Increased fertility and efficiency simulations revealed that there is increased net benefits to the society .They are corrective measures used to mitigate the negative impact of degradation on the ecology of the rangelands. Increased fertility is achieved by the application of fertilizers, which rejuvenate the rangelands and efficiency is achieved by the increased utilization and preservation of excess pastures to feed livestock in dry seasons. Degradation depicts depletion of pasture on the rangelands by overgrazing due to high stocking pressures in the open access.

On the other hand, increased social discount reduces the net present value of benefits, because people will get smaller and current payoffs compared to larger but future pay offs when the smaller payoffs are imminent. The observation by Farber *et al* (1993) is that the purpose of discounting is to favor present benefits over future benefits and generally favor regulations that produce short-term benefits and long-term costs. They further recommend that, with respect to the next generation, policymakers should use a low discount rate (probably around the social discount rate) because even a modest discount rate will favor small benefits conferred today over much larger benefits conferred in the distant future. Randall et al (2004) observed that a number of options such as reducing stocking rates, soil improvement by fertilizers, rotational grazing, use of weed herbicides and replanting to hold water tables are management tools that can be adopted in order to maintain rangelands on a sustainable basis. The findings of this research confirm that increasing soil fertility and efficiency are key management tools while degradation and increased social discount have negative impacts on the rangelands.

4.7 Harvest Levels

Table 9 presents hypothetical harvest levels in the optimal management and open access situations and the impact of selected management tools on the ecology of the rangeland in terms of the quantity of pasture available for grazing and harvesting for conservation per annum and for over a time horizon of 25 years. The 25 year time horizon is a hypothetical period illustrating sustainability.

Table 9: Hypothetical Harvest levels in Optimal and Open Access at different technologies

	Baseline		**Fertility at 1.20**		**Degrad. at 1.22**		**Efficiency at 0.3**		**Discount rate 25%**	
YEARS	OPT	OA	OPT	OA	OPT	OA	OPT	OA	OPT	OA
0	172	195	180	195	168	195	258	457	178	195
1	162	184	180	194	152	175	218	356	168	184
2	160	180	180	193	149	171	203	294	165	180
3	159	178	180	193	147	168	196	225	164	178
4	158	177	180	193	146	167	192	112	163	177
5	158	176	180	193	146	166	190	0	163	176
6	158	176	180	193	146	165	188	0	163	176
7	158	176	180	193	146	164	188	0	163	176
8	158	176	180	193	145	164	187	0	163	176
24	158	175	180	193	145	163	187	0	163	175
25	158	175	180	193	145	163	187	0	163	175

Source: Field Survey

The findings show that there are more quantities of biomass harvested in open access than in the optimal management system and sustainability is observed sooner in the latter than the former. Increased fertility led to increased quantity of grass harvested in both systems but the reverse is true with increased degradation. On the other hand, while increased efficiency greatly increased the quantity of harvests in both systems, however, it led to complete depletion of the biomass in a very short time. Lastly it was observed that increased levels of harvests occurred when the discount rate was increased.

The findings reveal that the harvest levels in the optimal management systems are less than in the open access systems. The pasture availability in the rangeland is translated into harvest levels in the simulation model to give an overview of the merits and demerits of the optimal and open access systems. In the optimal management system, the people use the pastures sparingly while in open access people use it in a communal manner and compete for it without thinking about tomorrow, thus ending up harvesting more. Hertzler (2005) observes that in open access, decisions are made as if the biomass was worthless. Hence, open access is a market failure because the price of biomass is missing. The overexploitation of the biomass eventually means that excessive harvesting is being done. Soil fertility increases the rate of growth of the biomass and this leads to more grass available for harvesting. Also efficiency leads to increased harvests in both optimal and open access systems because it improves the harvest per unit time and reduces the cost of harvesting. However, depletion quickly occurs in open access of the improved technology and no management restrictions. The implication here is that both technologies boost productivity but efficiency should only be used in the optimal management system as a technology to harness excess pastures often available in rainy seasons to be preserved for future use in the dry a season. If technical efficiency is used in the open access system, the pastures will be used up quickly and expose the land to degradation. Degradation catalyzes increased mortality rate of pastures and it reduces the quantity of grass available for harvesting. Clark (2001) noted that nutrient deterioration plays a role similar to depreciation in a capital model. The levels of harvests were observed to be higher when the discount rate was increased due to a tendency to over consume, because discounting favors regulations that confer benefits in the present or near future over regulations whose benefits society realizes at a later date, Farber et al (1993).

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY IMPLICATIONS

5.1 Summary

The study reveals that the majority, 54%, of the 240 respondents across the study area were willing to pay for the improved rangelands which would provide water and grass for livestock as well as maintaining the environment. However the WTP increased to 57% among the cattle keepers only. The respondents were willing to pay a mean amount of Shs 19,000 per square mile per annum but it was found that some individuals were renting grazing land at an average of Shs 58,000.

The major socioeconomic factors that affect the willingness to pay were found to be sex of respondents, mode of payment, education, possession of cattle, farming system, availability of water, payment of rent for grazing land, type of housing and land tenure system. The study revealed that male gender, possession of cattle, fenced farming, having inadequate water in the area and having property rights on land increased the chances and had statistically significant influence on the respondents' willingness to pay. On the other hand, the respondents who were already paying for the grazing land were more likely to be unwilling to pay for the improvement of the rangelands. The influence of mode of payment, education and type of housing of the respondents had no significant influence on the willingness to pay. Water was ranked second to schools when respondents were asked to put their needs in order of importance. Furthermore, results also reveal that, in response to scarcity of water and grass, some pastoralists sell off some livestock as a way of controlling the stock numbers, others use supplementary feeds while the majority moves to a new area.

This led to the conclusion that one of the reasons why the pastoralists move from place to place is because of looking for water for their livestock and own consumption because 97% respondents preferred to stay in one place if enough water and grass were provided in the grazing land. Unfortunately the majority of cattle keepers in the rangelands get water from natural sources while the government source is only 6%.

Total economic benefit and expected revenue were computed using the 57% WTP of cattle keepers only, the mean WTP of Shs 19,000 /sq mile per annum, mean actual rent of Shs 58,000/sq mile per annum and the households figures (UBOS, 2005/06). The total economic benefits from the improved rangelands at mean WTP fee were 14.0 billion Uganda Shillings in the cattle corridor and 24.9 billion for all cattle keeping households in the country. Using the actual rent, the economic benefits were 42.7 billion in the cattle corridor and 76.0 billion Uganda Shillings for the whole the country. On the other hand the expected revenues at mean willingness to pay value were 8.0 billion Uganda Shillings in the cattle corridor and 14.2 billion Uganda Shillings from all cattle keeping households. When the actual rent paid at the time was used, the expected revenues were 24.4 billion and 43.3 billion Uganda Shillings for the cattle corridor and all households respectively.

In all simulations, dynamic benefit values were found to be higher in optimal management than in the open access systems. It was also found that in optimal management all the three categories of people in the community get benefits while in the open access system the rent is not realized. Simulations of increased fertility and efficiency showed increased net benefits to the society while degradation and increased social discount reduces the net present value of benefits.

Simulations of harvest levels of pasture revealed that there are more quantities of biomass harvested in open access than in the optimal management system and sustainability is observed sooner in the latter than the former. Increased fertility led to increased quantity of grass harvested in both systems but the reverse is true with increased degradation. Increased efficiency greatly increased the quantity of pasture harvested but it leads complete depletion of the biomass in a very short time. Lastly it was observed that increased levels of harvests occurred when the discount rate was increased.

5.2 Conclusions and Policy Implications

The research reveals that the pastoralists and other cattle keepers who use open access systems are capable and willing to pay an annual fee to maintain improved rangelands with adequate pastures and water. The estimated returns and total economic benefit of the program are substantial, meaning that rehabilitation of the rangelands is a viable venture and it is of economic importance to the country. Analysis of benefits also shows that in the optimal management system of keeping livestock all the people in the community benefit. However, in open access systems some members in community miss out and the system is unsustainable as it leads to degradation. This eventually becomes a national and global environmental externality because it affects even people living away from the rangelands.

In conclusion, therefore, the findings are a testimony that there is need for policy makers to internalize the institutional, economic, cultural and social interests of the local community in addition to the ecological dynamics in the rangeland in order to design appropriate strategies for rehabilitation and sustainable management of natural resources. As an example, the failure of the management of valley dams in the Livestock Services Project was due to the fact that the infrastructure was build and left for communal use without involvement of any the community entity to manage it.

This research could serve as a motivation for the government to intervene and expedite formulation of a comprehensive land use and rangeland policies with clear guidelines and enforceable regulations on how public and private land should be used in a manner that increases livestock production but does not endanger the social and sustainable use of the rangelands and environment. It is economically prudent for the Government to invest in into the rehabilitation of the rangelands including water sources and creates Range Land Management Units (similar to the Beach Management Units in Fisheries) as a community involvement to manage the resource on a cost sharing basis.

6.0 REFERENCES

Alemu Mekonnen, 2000. "*Valuation of community forestry in Ethopia: a contingent valuation study of rural households" Environment & development Economics,* 5 289-308.

Chesham S.A.O and J.B. Nduwayezu, 2002. "*Rehabilitation of Degraded Sub-humid Lands in Sub-Saharan Africa:"* A synthesis - Sokoine University of Agriculture

Clark (2001) "*An Assessment of the Economic, Environmental and Social Impacts of NSW Agriculture's Investment in the Net Feed Efficiency R, D&E Cluster*", Economic Research Report No. 18

Common Wealth of Austrailia, 1992."Economically Sustainable Development, AGPS, Canberra."(p.6)

Pearce David W. and R.Kerry Turner, 1990. "*Economics of Natural Resources and the Environment".* Publisher: Harvester Wheatsheaf,Campus 400 Maylands Aveue, Hemel Hempstead, Herfordshire,HP2 7EZ.

Dasgputa, P. and Heal, G.M, 1979. *Economic theory and exhaustible resources.* James Nisbet & Co./Cambridge University Press, Welwyn UK.

Emerton L. and E. Muramira, 1999."Uganda Biodiversity: Economic Assessment" NEMA

Farber, D. A., and P. A. Hemmersbaugh, 1993. The shadow of the future: Discount ates, later generations, and the environment. *Vanderbilt Law Review* 46: 267-304.

Gartner J. A. 1998: "*Replacement policy in dairy herds on farms where heifers compete with cows for grassland*"; A review of bio-economic simulation models of beef production Analysis and synthesis Vol 58:

Garoian Lee, James W. Mjelde and J. Richard Conner, 1990. *"Optimal Strategies for Marketing Calves and yearlings from Rangeland".*AJAE, 72(3) (Aug.) 604-13.

Hartwick, J, 1977. "*Intergenerational Equity and the Investing of rents from exhaustible Resources" American Economic Review* 65972-974.

Hertzler G, 2005. "*Economics of natural Resources"* Center for Environmental Economics and Policy in Africa, CEEPA

James D. Gwartney, 1977."*Microeconomics-Private and Public Choice, p75."*

Kamanyire Marilyn, 2000."*Natural Resource Management and Policy in Uganda: Overview Paper"* Economic Policy Research Centre

Kamanyire Marilyn, 2000. *Natural resources Management and policy in Uganda.* Department for International Research Project No.R7076CA.

Kanyangareng, 2007. "*Pastoralists are misunderstood":* Daily Monitor News paper, July 12.

Katherine M. Homewood, 2004. "*Policy, environment and development in African rangelands"* Department of Anthropology, University College London, Gower Street, London WC1E 6 BT, UK, Environmental Science & Policy 7, 125–143

Khaukha, Robert, 1992. "*An Economic Analysis of Demand and supply of Agricultural Inputs at farm level: Case Study of Cotton Pesticides in Iganga District*

Kisamba W. Mugerwa, 2001. *" Rangelands Management Policy in Uganda"* International Conference on Policy & Institutional Options for Management of Rangelands In Dry Areas.

Kisamba W. Mugerwa, J. Pander, E. Kato, 2006. "*Impacts of Individualization of Land Tenure on Livestock and Rangeland Management in Southwestern Uganda"* International Food Policy Research Institute: Paper to be presented at the 11th Biennial Conference of the International Association for the Study of Common Property in Bali, Indonesia.

Köhlin, G ,1997. "*Contingent Valuation in Project Planning and Evaluation:The case of social forestry in Orissa, India. Studie in Environmental Economics and Development*" Environmental Economics Unit, Göteborg University.

Kyagaba Emmanuel , 2004. "*Range Resource Assessment and Monitoring Techniques among the Pastoral Bahima in Uganda*": Nomadic Peoples, Vol. 8.

Lumby, 2005. "*Environmental Valuation Policy",* Center for Environmental Economics and Policy in Africa.

Lynam, T.J.P.,B.M. Campbell and S.J Vermeulen, 1994. "*Contingent Valuation of Multipurpose tree resource in the small holder farming sector, Zimbabwe, Studies in Environmental Economics and Development*", 8. Environmental Economics Unit Göteborg University.

MAAIF, 1990. *"Meat Master Plan"*

MAAIF, 1999. *"Framework for the national action Programme to combat desertification and Drought in Uganda"* The way forward in implementing the United Nations Convention to Combat Desertification

MAAIF, 2000. "*Plan for Modernization of Agriculture: Seventh pillar*"

MAAIF, 2004. "*Draft of the Rangeland Policy"*

MAAIF, 2004. *"Livestock Development Strategy"*

McConnell, K.E and Ducci JH, 1989. "*Valuing Environmental Quality in Developing Countries: Two case Studies",* Paper presented at Allied Social Science, Atlanta, Georgia.

MoFPED, 2007. "*Approved estimates of Revenues and Expenditure - recurrent and Development"*: Ministry of Finance, Planning and Economic Development.

Mwebaze S.M, 1999. "*Pasture/Forage Resource Profile for Uganda*". FAO website.

Mwilawa A. J., D. M. Komwihangilo and M. L, 2008. *Conservation of forage resources for increasing livestock production in traditional forage reserves in Tanzania":* National Livestock Research Institute (NLRI), Agricultural Research Institute, Tumbi: 2008 Blackwell Publishing Ltd, Afr. J. Ecol., 46 (Suppl. 1), 85–89

Nkonya Ephraim, John Pender, Pamela Jagger, Dick Sserunkuuma, Crammer Kaizzi and Henry Ssali (2004), "*Strategies for Sustainable Land Management and Poverty Reduction in Uganda*" Research Report 133: International Food Policy Research Institute, Washington, DC

North, J.K and Griffin, C.G, 1993. "*Water Source as a Housing Characteristic: Hedonic Property Valuation and Willingness to pay for Water" Water Resources Research, 29 (7)pp. 1,923-1,929.*

Olson J., L. Berry (2004) "*Land Degradation in Uganda: Its Extent and Impact*" Commissioned by Global Mechanism with support from the World Bank.

Phil Frank et al, 2003. "*Participatory Environmental management: Rangelands in Uganda, Engaging the Rural Poor as Partners in conservation".* Institute for International Studies, Anita, Pederson, DOF-BirdLife.

Randall Jones and Peter Dowling, 2005. "*Sustainability and economics of temperature perennical Australia Grazing Systems".* Agriculture, Ecosystem & Environ. 106(4) 359-76.

Rashid M., 2002. "*Accounting for stock and flow values of woody Land Resource*" Center for Environmental Economics and Policy in Africa

Ray Huffaker G, James E. Wilen, 1991. "*Animal Stocking Under Conditions of Declining Forage Nutrients".* AJAE 731213 -23.

Sabiiti E.N: "*Grasslands, 2004. A Resource for Humanity*" Inaugural Lecture, Makerere University.

Sabiiti E. N. and Tegegne Teka, 1994. Research and Pastoral Resource Management in Uganda: Makerere University.

Sabiiti E.N, Mpairwe, D.,Rwakakaikara-Silver M and S. Mugasi, 2004. "*Restoration of degraded grasslands to enhance soil fertility, pasture and animal productivity".* Uganda Journal of Agricultural Sciences. Vol. 9(1). 466-469.

Sserunkuuma D and Oslon K, 1998. "*Externalities, Risk and the Private Property-Overgrazing Paradox: The case of Private Cattle Farms in Nyabushozi County, Uganda.* Center for International Food and Agricultural Policy, Working Paper WP98-1.

Sserunkuuma D and Runge F, 1998. "*Rangeland Degradation in Uganda: The Failures and Future Of Privatization'.* Center foe International Food and Agricultural Policy, Working Paper WP98-2.

Shyamsundar P. and R. Kramer, 1996. "*Tropical Forest Protection: An empirical analysis of the costs borne by local people".* Journal of Environmental Economics and Management: 31 129-44.

Stanford, 1993. "*Management of Pastoral Development in Third World*": Overseas Development Institute, London.

Toxopeus A G, 1992. "*Spartial and Temporal Modeling for Sustainable Management of Semi- Arid Rangelands: the wild life Versus Live Stock issue in the Amboseli Ecosystem, Southern Kenya".* ITC Publications, ACE Division, Netherlands.

UBOS, 2007. Uganda National Household Survey 2005/2006 "*Report on the Agricultural Module*", p.142-144

UBOS, 2008. Statistical Abstract, p.173 - 203

UBOS, 2009. The National Livestock Census "*A Summary of the National Livestock Census, 2008"*, p.8 – 14

Umrani Aslam Pervez (1998):" *Sustainable Approaches in arid and semi-arid Regions of Tropical countries". Pakistan Journal pp* 1-11.

United Nations, 1987. "*World Commission on Environment*"

Wabwire Ernest, 1993. "*Pastoral Crisis and Transformation: An Evaluation of the Role of Non-Governmental Organizations in Karamoja*" Centre for Basic Research, Kampala.

Weitzman. M.L, 1976. "*On the welfare significance of national product in the dynamic Economy" Quarterly Journal of Economics* 90, 156-162

Wittington D.,Lauria D.T., Wright A., Choe K., Hughes J., and Swarn V, 1993. *"Household Demand for Improved Sanitation Services in Kumasi Ghaha: A Contingent Valuation Study".* Water Resource, *29,* 1,539-1,560.

APPENDICES

AI: RESEARCH QUESTIONNAIRE

District………………………………. Date……………………..

Sub County……………………………... ID No……………………….

SECTION 1: Terms for improving the rangelands

There is a program intended to rehabilitate the grassland in your area. Grass will be replanted and permanent trees will also be planted in the area to provide shades for your animals. Permanent sources of water will be constructed so that you will no longer need to move long distances to water your animals (show pictures) you will be able to stay in one place permanently, build yourself houses so that the government builds schools, dispensaries, roads and eventually electricity in your area. (Show pictures of good settlements)

However when these things are put in place, they need maintenance so that they last forever. The government intends to ask all people with cattle to contribute. Every person in the community will be required to contribute either cash or in kind in terms of small goats or cattle per year so that this infrastructure belongs to you.

1) Are you in position to pay some money every year to maintain these amenities?

   ☐ Yes = 1 No= 2

2) If yes are you willing to pay only 50,000/= a year for all your animals to have enough grass and waste?

   ☐ Yes = 1 No = 2

3) How about if the money is 100,000/= per year?

   ☐ Yes = 1 No = 2

4) If no, how much are you willing to contribute for the good of your animals?

   ☐

5) How would you like to pay, cash or in kind?

   ☐ Cash = 1 Kind = 2

B2: RESEARCH QUESTIONNAIRE

District………………………………. Date……………………..

Sub County……………………………….. ID No……………………….

SECTION 1: Terms for improving the rangelands

There is a program intended to rehabilitate the grassland in your area. Grass will be replanted and permanent trees will also be planted in the area to provide shades for your animals. Permanent sources of water will be constructed so that you will no longer need to move long distances to water your animals (show pictures) you will be able to stay in one place permanently, build yourself houses so that the government builds schools, dispensaries, roads and eventually electricity in your area.

However when these things are put in place, they need maintenance so that they last forever. The government intends to ask all people with cattle to contribute. Every person in the community will be required to contribute either cash or in kind in terms of small goats or cattle per year so that this infrastructure belongs to you.

1) Are you in position to pay some money to maintain these amenities?

   ☐ Yes =1 No = 2

2) If yes, are you willing to pay only 100,000/= a year for all your animals to have enough grass and waste?

   ☐ Yes = 1 No = 2

3) How about if the money is 50,000/=

   ☐ Yes = 1 No = 2

4) If no, how much are you willing to contribute for the good of your animals?

   ☐

5) How would you like to pay, cash or kind?

   ☐ Cash = 1 Kind = 2

SECTION 2: Demographic Characteristics

ID of Household Respondent ☐	Sex ☐	Age in complete years ☐	Relationship to household ☐	Marital Status ☐	Highest level achieved ☐
(1)	(2)	(3)	(4)	(5)	(7)

	Male 1 Female 2		Head 1 Spouse 2 Employee 3 Others 4	Married 1 Not Married 2	Below P1 1 P1-p4 2 P4-p7 3 S1-S4 4 S5 and above 5

Length of time household stayed in the area	Reason for short staying	Type of house	Number of children in the household	Do you have school going children?	Source of livelihood
(7)	(8)	(9)	(10)	(11)	(12)
		Permanent 1 Semi-Permanent 2 Temporary 3		Yes 1 No 2	Working 1 Cattle keeping 2 Agriculture 3 Business 4 Others 5

SECTION 3: Perception and Socio-economic Characteristics.

Type of cattle keeping	How many heads of cattle do you have	Ownership of grazing land	Do you have enough grass and water all the year round	Who provides the water in the grazing land
(1)	(2)	(3)	(4)	(5)
Farm 1 Traditional 2		Self 1 Community Family 3 Government 4 Private 5	Yes 1 No 2	Nature 1 Self 2 Community 3 Government 4 NGO 5

Are you charged for used land	How do you pay	How much do you pay	What do you do when drought comes	What other feeds do you give in dry seasons	Would you like to stay in one place permanently if grass & water is there?
(6)	(7)	(8)	(9)	(10)	(11)
Yes 1 No 2	Cash 1 Kind 2		Sell animals 1 Move to new area 2 Buy feeds 3		Yes 1 No 2

Do you get problems when you move looking for grass & water?	List some of the problems	If animals are sick, do you pay for treatment?	How many animals do you sell per month?	List most important things you spend on	Put in order things you would like the government to assist
(12)	(13)	(14)	(15)	(16)	(17)
Yes 1 No 2		Yes 1 No 2			School 1 Dispensary 2 Water 3 Grass 4 Electricity 5 Others 6

B: STATA Analysis do-file

```
use "C:\Documents and Settings\DR\Desktop\thesis 17th august 2008.dta", clear
ta  s1q1
keep if  s1q1==1 ///**confining analysis to those willing to pay some money**///
ta   s1q2   ////*****to estalish those willing to pay 100, 000/= *********/////
keep if  s1q2==2 ///***confining analysis to those willing to pay less than 100,0000***///

ta   s1q3   ////*****to estalish those willing to pay 50, 000/= *********/////
keep if  s1q3==2 ///***confining analysis to those willing to pay less than 50,0000***///
collapse (mean) s1q4  ///***to compute average amount for those WTP less than 50,0000***///
ta s1q5   ////*****to estalish mode of payment *********/////

keep if  s3q2<. ///*********to retain only those household that own cattle*********///
ta s1q1 ///****to establish the willingness to pay for ONLY cattle keeprs****///

use "C:\Documents and Settings\DR\Desktop\thesis 17th august 2008.dta", clear
tab s2q2 ///*** to establish the sex proportion of the respondents***///
collapse (mean) s2q3  ///***to compute average age of the respondents ***///
ta s2q3   ////*****average age of respondents *********/////

use "C:\Documents and Settings\DR\Desktop\thesis 17th august 2008.dta", clear
ta s2q4 ///*** to etsblish the relationship to the household****///
ta s2q5 ///*** to establish marriage status***///

use "C:\Documents and Settings\DR\Desktop\thesis 17th august 2008.dta", clear
ta s2q6 ///***to tabulate the number of years in school***///
gen  educ1= educ
gen  educ2=educ1-2 ///***to get median level of education for each education interval***///
save "C:\Documents and Settings\DR\Desktop\thesis 17th august 2008.dta", replace
collapse (mean)   educ2 ///*** to compute average number of years in school***///
ta educ2 ///*** average number of years in school***///

use "C:\Documents and Settings\DR\Desktop\thesis 17th august 2008.dta", clear
keep if  s3q2<.    //*********to retain only those household that own cattle****///
ta s2q9 ///*** etablish type of house a cattle keeper lives in ******////

use "C:\Documents and Settings\DR\Desktop\thesis 17th august 2008.dta", clear
keep if  s3q2<.    //*********to retain only those household that own cattle****///
ta s3q1 ///*** establish system of cattle keepers*****////
collapse (mean) s3q2 ///***to compute average number of cattle owned****////
ta s3q2 ///*** average number of cattle****////

use "C:\Documents and Settings\DR\Desktop\thesis 17th august 2008.dta", clear
keep if  s3q2<.  //*********to retain only those household that own cattle********///
ta s3q3 ///*****to get proportion of land ownership by cattle keepers****///
ta s3q4 ///***** proportion of cattle keepers with adequate water & grass ****///
ta s3q5 ///*****proportion of sources of water in the study area*****////
ta s3q6 ///*****proportion of cattle keepers already renting the land***///
ta s3q7 ///****payment method of cattle keepers renting land****///
drop if  s3q6>1 ///***to retain only those household that charged for using land***///
collapse (mean) s3q8 /// ***to compute average amount paid for using land******///
ta s3q8 ///****mean amount of rent******////

use "C:\Documents and Settings\DR\Desktop\thesis 17th august 2008.dta", clear
keep if  s3q2<. ///*********to retain only those household that own cattle*********///
ta s3q9  ///***response of cattle keepers to inadequate water and grass*******/////
ta  s3q10, miss    ///****establishing feeds supplemented during dry season******////
ta s3q11 ///****option to stay in one place if adequate water and grass was present**//
ta s3q12 /// to establish whether respondents get problems when moving to places***///
ta s3q14 ///*****proportion of cattle keepers that pay for treatment****///
ta s3q17 ///***rank of what respondents wish government to do for them*****////


////*********labelling district***************////
use "C:\Documents and Settings\DR\Desktop\thesis 17th august 2008.dta", clear
label define dist 1 "mbarara"
label define dist 2 "nakapiripirit", add
```

```
label define dist 3 "nakasongola", add
label define dist 4 "mukono", add
label values dist dist
ta  dist

//////**********to analyse each district separately, use keep command************///////

use "C:\Documents and Settings\DR\Desktop\thesis 17th august 2008.dta", clear
keep if dist ==1  ///******to retain mbarara only************///////
tabulate s1q1
use "C:\Documents and Settings\DR\Desktop\thesis 17th august 2008.dta", clear
ta  s1q1
drop if  s1q1==2 ///********confining analysis to those willing to pay some money******///
ta   s1q2   ////*****to establish those willing to pay 100, 000/= *********/////
keep if  s1q2==2  ///********confining analysis to those willing to pay less than 100,0000***///
ta   s1q3   ////*****to establish those willing to pay 50, 000/= *********/////
keep if  s1q3==2  ///********confining analysis to those willing to pay less than 50,0000***///
collapse (mean) s1q4 /// ***to compute average amount for those WTP less than 50,0000***///
ta s1q5   ////*****to establish mode of payment *********/////
//// repeat all the commands to all the responses per district***************************//////

////*********MODELLING**************//////

use "C:\Documents and Settings\DR\Desktop\thesis 17th august 2008.dta", clear
keep if  s3q2<.    //********to retain only those household that own cattle************///

gen sex=1
replace sex =0 if s2q2==2 ///****genarating dummy for sex and male=1, female otherwise***///

gen cash=1
replace cash=0 if s1q5==2 ///***dummy for paying cash or kind****///

gen cattle==s3q2 ///****number of cattle owned by respondents*****////

gen  educ1= educ
gen  educ2=educ1-2 ///***to get median level of education for each educ interval ****///

gen nowater=1
replace nowater=0 if s3q4==1 ///*****dummy for availanility of water and grass***////
logit WTP nowater, or

gen charged =1
replace charged =0 if s3q6==2 ///****dummy for respondents renting*****///

destring s3q3, gen(land)
gen property=1 ///****property right when land is self, family and private****////
replace property=0 if land==2
replace property=0 if land==4
ta property
logit WTP property nowater, or

gen farms=1
replace farms=0 if s3q1==2 ///****dummy for fenced farm as 1 and traditional as 0 ****///
ta farms
logit WTP farms property nowater, or

gen houses=1
replace houses=0 if s2q9>2
ta houses
logit WTP  houses farms property nowater, or

gen permhouse=1
replace permhouse=0 if s2q9>1 ///****dummy if permnent house and or semi is 1 *****///
ta permhouse

logit WTP  permhouse farms property nowater, or
logit WTP  sex cash  educ2 farms property nowater, or
logit WTP  sex cash  educ2 permhouse farms nowater, or
logit WTP  sex cash  educ2 permhouse farms property nowater, or
logit WTP  sex cash educ2 cattle farms nowater charged permhouse property, or
```

C: BENEFITS AND HARVESTS SIMULATION WORK SHEETS

C1: Baseline Optimal Management

Rangeland Management

Baseline Optimal Management

Demand		Effort Technology		Growth		Mortality		Fertility Technology	
Scale parameter	1200.00	Effort flexibility	1.60000	Intrinsic rate	0.50000	Intrinsic rate	0.04020	Fertilizer	1.0000
Price flexibility	0.80000	Stock elasticity	0.40000	Environment 1	1.00000	Environment 1	1.00000	Degradation Factor	1.02
Shift parameter	40.00	Consumption rate	0.15000	Environment 2	0.00001	Environment 2	0.00251		

Other Parameters		Net Present Values			
Discount rate	0.02000	Total Willing to Pay	241451.65	Consumer Surplus	100742.70
Price of effort	1.50000	Total Effort Cost	-73512.37	Total Rent	23089.15
Initial biomass	900	Net Benefits	167939.27	Producer Surplus	44107.42
				Net Benefits	167939.27

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UNDISCOUNTED VALUES

Year	Biomass	Growth	Mortality	Harvest	Effort	Total Will Pay	Total Effrt Cost	Net Benefits	Price of Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	900	446	353	172	1008	4963	1512	3452	16.54	14.08	1.56	422	-194	3257	2123	907
1	821	407	264	163	978	4808	1467	3340	17.14	14.45	2.46	437	-53	3288	2022	880
2	801	397	246	160	968	4762	1452	3311	17.32	14.53	2.69	446	-22	3288	1993	871
3	793	394	238	159	963	4743	1445	3298	17.40	14.56	2.79	450	-10	3288	1981	867
4	790	392	235	158	961	4734	1442	3293	17.43	14.58	2.84	452	-5	3288	1975	865
5	788	391	234	158	960	4730	1440	3290	17.45	14.58	2.86	453	-2	3288	1973	864
6	788	391	233	158	960	4729	1440	3289	17.46	14.59	2.87	454	-1	3288	1972	864
7	787	390	233	158	959	4728	1439	3288	17.46	14.59	2.87	454	0	3288	1971	864
8	787	390	233	158	959	4727	1439	3288	17.46	14.59	2.88	454	0	3288	1971	863
9	787	390	233	158	959	4727	1439	3288	17.46	14.59	2.88	454	0	3288	1971	863
10	787	390	233	158	959	4727	1439	3288	17.47	14.59	2.88	454	0	3288	1970	863
11	787	390	233	158	959	4727	1439	3288	17.47	14.59	2.88	454	0	3288	1970	863
12	787	390	233	158	959	4727	1439	3288	17.46	14.59	2.88	454	0	3288	1971	863
13	787	390	233	158	959	4727	1439	3288	17.46	14.59	2.88	454	0	3288	1971	864
14	787	390	233	158	960	4728	1439	3288	17.46	14.59	2.87	453	0	3288	1971	864
15	787	390	232	158	960	4727	1439	3288	17.46	14.59	2.87	453	0	3288	1971	864
16	787	390	232	158	960	4727	1439	3288	17.46	14.59	2.87	454	0	3288	1971	864
17	787	390	232	158	960	4727	1439	3288	17.46	14.59	2.87	454	0	3288	1971	864
18	787	390	232	158	959	4727	1439	3288	17.46	14.59	2.87	454	0	3288	1971	863
19	787	390	232	158	959	4726	1438	3288	17.47	14.59	2.88	455	0	3288	1970	863
20	787	390	233	158	959	4726	1438	3288	17.47	14.59	2.88	455	0	3288	1970	863
21	787	390	233	158	959	4727	1439	3288	17.46	14.59	2.88	454	0	3288	1971	863
22	787	390	233	158	960	4728	1440	3288	17.46	14.59	2.88	453	0	3288	1971	864
23	787	390	232	158	960	4728	1440	3288	17.46	14.59	2.87	453	0	3288	1971	864
24	787	390	232	158	959	4726	1438	3288	17.47	14.59	2.87	455	0	3288	1970	863
25	787	390	233	158	959	4727	1439	3288	17.46	14.59	2.88	454	0	3288	1971	863
26-infnty	787					241074	73389	167685			2.88	23151	0	167685	100500	44034

DISCOUNTED VALUES

Year	Total Will Pay	Total Effrt Cost	Net Benefits	Price Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	4963	1512	3452	16.54	14.08	1.60	422	-194	3257	2123	907
1	4714	1439	3275	16.80	14.17	2.46	429	-52	3223	1983	863
2	4577	1395	3182	16.65	13.97	2.64	429	-21	3161	1916	837
3	4470	1362	3108	16.40	13.72	2.68	424	-9	3099	1867	817
4	4374	1332	3042	16.11	13.47	2.67	418	-4	3038	1825	799
5	4284	1304	2980	15.81	13.21	2.64	411	-2	2978	1787	783
6	4199	1278	2921	15.50	12.95	2.60	403	-1	2920	1751	767
7	4116	1253	2863	15.20	12.70	2.55	395	0	2862	1716	752
8	4035	1228	2806	14.90	12.45	2.50	388	0	2806	1682	737
9	3955	1204	2751	14.61	12.21	2.46	380	0	2751	1649	722
10	3878	1180	2697	14.33	11.97	2.41	373	0	2697	1616	708
11	3801	1157	2644	14.05	11.73	2.36	365	0	2644	1585	694
12	3727	1135	2593	13.77	11.50	2.32	358	0	2593	1554	681
13	3654	1113	2542	13.50	11.28	2.27	351	0	2542	1523	668
14	3583	1091	2492	13.23	11.06	2.22	344	0	2492	1494	655
15	3513	1070	2443	12.97	10.84	2.18	337	0	2443	1464	642
16	3444	1048	2395	12.72	10.63	2.13	330	0	2395	1436	629
17	3376	1028	2348	12.47	10.42	2.09	324	0	2348	1407	617
18	3310	1007	2302	12.23	10.21	2.05	318	0	2302	1380	604
19	3244	987	2257	11.99	10.01	2.01	312	0	2257	1352	592
20	3181	968	2213	11.76	9.82	1.98	306	0	2213	1326	581
21	3119	949	2169	11.52	9.62	1.94	300	0	2169	1300	570
22	3058	931	2127	11.29	9.44	1.90	293	0	2127	1275	559
23	2998	913	2085	11.07	9.25	1.86	287	0	2085	1250	548
24	2938	894	2044	10.86	9.07	1.82	283	0	2044	1225	537
25	2881	877	2004	10.65	8.89	1.79	277	0	2004	1201	526
26-infnty	144061	43856	100205			1.75	13834	0	100205	60057	26314

C2: Baseline Open Access.

Rangeland Management

Baseline Open Access

Demand		Effort Technology		Growth		Mortality		Fertility Technology	
Scale parameter	1200.00	Effort flexibility	1.60000	Intrinsic rate	0.50000	Intrinsic rate	0.04020	Fertilizer	1.0000
Price flexibility	0.80000	Stock elasticity	0.40000	Environment 1	1.00000	Environment 1	1.00000	Degradation Factor	1.02
Shift parameter	40.00	Consumption rate	0.15000	Environment 2	0.00001	Environment 2	0.00251		

Other Parameters		Net Present Values			
Discount rate	0.02000	Total Willing to Pay	256835.91	Consumer Surplus	110672.56
Price of effort	1.50000	Total Effort Cost	-91352.09	Total Rent	0.00
Initial biomass	900	Net Benefits	165483.81	Producer Surplus	54811.26
				Net Benefits	165483.81

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UNDISCOUNTED VALUES

Year	Biomass	Growth	Mortality	Harvest	Effort	Total Will Pay	Total Effrt Cost	Net Benefits	Price of Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	900	446	353	195	1237	5335	1855	3480	15.21	15.21	1.29	0	0	3480	2367	1113
1	797	396	242	184	1211	5155	1817	3338	15.84	15.84	0.00	0	0	3338	2248	1090
2	767	381	216	180	1203	5098	1805	3293	16.04	16.04	0.00	0	0	3293	2211	1083
3	752	373	204	178	1199	5069	1798	3270	16.15	16.15	0.00	0	0	3270	2191	1079
4	744	369	197	177	1196	5052	1795	3257	16.21	16.21	0.00	0	0	3257	2180	1077
5	738	366	193	176	1195	5041	1792	3249	16.25	16.25	0.00	0	0	3249	2173	1075
6	735	365	191	176	1194	5035	1791	3244	16.27	16.27	0.00	0	0	3244	2169	1075
7	733	364	189	176	1193	5031	1790	3241	16.29	16.29	0.00	0	0	3241	2167	1074
8	732	363	188	176	1193	5028	1790	3239	16.30	16.30	0.00	0	0	3239	2165	1074
9	731	363	188	176	1193	5027	1789	3238	16.30	16.30	0.00	0	0	3238	2164	1074
10	731	363	187	176	1193	5026	1789	3237	16.31	16.31	0.00	0	0	3237	2163	1073
11	730	362	187	175	1193	5025	1789	3236	16.31	16.31	0.00	0	0	3236	2163	1073
12	730	362	187	175	1193	5025	1789	3236	16.31	16.31	0.00	0	0	3236	2163	1073
13	730	362	187	175	1192	5024	1789	3236	16.31	16.31	0.00	0	0	3236	2162	1073
14	730	362	187	175	1192	5024	1789	3235	16.31	16.31	0.00	0	0	3235	2162	1073
15	730	362	187	175	1192	5024	1789	3235	16.31	16.31	0.00	0	0	3235	2162	1073
16	730	362	187	175	1192	5024	1789	3235	16.31	16.31	0.00	0	0	3235	2162	1073
17	730	362	187	175	1192	5024	1789	3235	16.31	16.31	0.00	0	0	3235	2162	1073
18	730	362	187	175	1192	5024	1789	3235	16.31	16.31	0.00	0	0	3235	2162	1073
19	730	362	187	175	1192	5024	1789	3235	16.31	16.31	0.00	0	0	3235	2162	1073
20	730	362	187	175	1192	5024	1789	3235	16.31	16.31	0.00	0	0	3235	2162	1073
21	730	362	187	175	1192	5024	1789	3235	16.31	16.31	0.00	0	0	3235	2162	1073
22	730	362	187	175	1192	5024	1789	3235	16.31	16.31	0.00	0	0	3235	2162	1073
23	730	362	187	175	1192	5024	1789	3235	16.31	16.31	0.00	0	0	3235	2162	1073
24	730	362	187	175	1192	5024	1789	3235	16.31	16.31	0.00	0	0	3235	2162	1073
25	730	362	187	175	1192	5024	1789	3235	16.31	16.31	0.00	0	0	3235	2162	1073
26-infnty	730					256214	91218	164996			0.00	0	0	164996	110265	54731

DISCOUNTED VALUES

Year	Total Will Pay	Total Effrt Cost	Net Benefits	Price Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	5335	1855	3480	15.21	15.21	1.32	0	0	3480	2367	1113
1	5054	1781	3272	15.53	15.53	0.00	0	0	3272	2204	1069
2	4900	1735	3166	15.42	15.42	0.00	0	0	3166	2125	1041
3	4776	1695	3082	15.22	15.22	0.00	0	0	3082	2065	1017
4	4667	1658	3009	14.98	14.98	0.00	0	0	3009	2014	995
5	4566	1623	2943	14.72	14.72	0.00	0	0	2943	1969	974
6	4471	1590	2881	14.45	14.45	0.00	0	0	2881	1926	954
7	4380	1558	2821	14.18	14.18	0.00	0	0	2821	1886	935
8	4292	1527	2764	13.91	13.91	0.00	0	0	2764	1848	916
9	4206	1497	2709	13.64	13.64	0.00	0	0	2709	1811	898
10	4123	1468	2655	13.38	13.38	0.00	0	0	2655	1775	881
11	4041	1439	2603	13.12	13.12	0.00	0	0	2603	1740	863
12	3962	1410	2551	12.86	12.86	0.00	0	0	2551	1705	846
13	3884	1383	2501	12.61	12.61	0.00	0	0	2501	1672	830
14	3808	1356	2452	12.36	12.36	0.00	0	0	2452	1639	813
15	3733	1329	2404	12.12	12.12	0.00	0	0	2404	1607	797
16	3660	1303	2357	11.88	11.88	0.00	0	0	2357	1575	782
17	3588	1277	2311	11.65	11.65	0.00	0	0	2311	1544	766
18	3518	1252	2265	11.42	11.42	0.00	0	0	2265	1514	751
19	3449	1228	2221	11.20	11.20	0.00	0	0	2221	1484	737
20	3381	1204	2177	10.98	10.98	0.00	0	0	2177	1455	722
21	3315	1180	2135	10.76	10.76	0.00	0	0	2135	1426	708
22	3250	1157	2093	10.55	10.55	0.00	0	0	2093	1399	694
23	3186	1134	2052	10.35	10.35	0.00	0	0	2052	1371	681
24	3123	1112	2011	10.14	10.14	0.00	0	0	2011	1344	667
25	3062	1090	1972	9.94	9.94	0.00	0	0	1972	1318	654
26-infnty	153108	54510	98598			0.00	0	0	98598	65892	32706

C3: Optimal management at Fertilizer Increase by 20% others constant.,

Rangeland Management

Opimal Management at fertilizer Increase by 20%

Demand		Effort Technology		Growth		Mortality		Fertility Technology	
Scale parameter	1200.00	Effort flexibility	1.60000	Intrinsic rate	0.50000	Intrinsic rate	0.04020	Fertilizer	1.2000
Price flexibility	0.80000	Stock elasticity	0.40000	Environment 1	1.00000	Environment 1	1.00000	Degradation Factor	1.02
Shift parameter	40.00	Consumption rate	0.15000	Environment 2	0.00001	Environment 2	0.00251		

Other Parameters		Net Present Values			
Discount rate	0.02000	Total Willing to Pay	259911.13	Consumer Surplus	112679.03
Price of effort	1.50000	Total Effort Cost	-82871.35	Total Rent	14637.95
Initial biomass	900	Net Benefits	177039.79	Producer Surplus	49722.81
				Net Benefits	177039.79

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UNDISCOUNTED VALUES

Year	Biomass	Growth	Mortality	Harvest	Effort	Total Will Pay	Total Effrt Cost	Net Benefits	Price of Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	900	535	353	180	1082	5091	1624	3468	16.07	14.47	1.62	287	4	3471	2206	974
1	902	537	356	180	1083	5096	1625	3471	16.05	14.45	1.60	287	1	3471	2209	975
2	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
3	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
4	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
5	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
6	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
7	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
8	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
9	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
10	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
11	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
12	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
13	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
14	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
15	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
16	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
17	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
18	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
19	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.60	287	0	3471	2209	975
20	903	537	357	180	1083	5097	1625	3471	16.05	14.45	1.60	287	0	3471	2210	975
21	903	537	357	180	1083	5097	1625	3471	16.05	14.45	1.59	287	0	3471	2210	975
22	903	537	357	180	1083	5097	1625	3471	16.05	14.45	1.59	287	0	3471	2210	975
23	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.59	287	0	3471	2209	975
24	903	537	357	180	1083	5097	1625	3471	16.05	14.45	1.60	287	0	3471	2210	975
25	903	537	357	180	1083	5096	1625	3471	16.05	14.45	1.59	287	0	3471	2209	975
26-infnty	903					259919	82874	177044			1.60	14636	0	177044	112684	49725

DISCOUNTED VALUES

Year	Total Will Pay	Total Effrt Cost	Net Benefits	Price Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	5091	1624	3468	16.07	14.47	1.65	287	4	3471	2206	974
1	4996	1593	3403	15.74	14.17	1.60	281	1	3403	2166	956
2	4898	1562	3337	15.42	13.89	1.56	276	0	3337	2123	937
3	4802	1531	3271	15.12	13.62	1.53	271	0	3271	2082	919
4	4708	1501	3207	14.83	13.35	1.50	265	0	3207	2041	901
5	4616	1472	3144	14.53	13.09	1.47	260	0	3144	2001	883
6	4525	1443	3083	14.25	12.83	1.45	255	0	3083	1962	866
7	4437	1415	3022	13.97	12.58	1.42	250	0	3022	1923	849
8	4350	1387	2963	13.70	12.33	1.39	245	0	2963	1886	832
9	4264	1360	2905	13.43	12.09	1.36	240	0	2905	1849	816
10	4181	1333	2848	13.16	11.86	1.34	236	0	2848	1812	800
11	4099	1307	2792	12.91	11.62	1.31	231	0	2792	1777	784
12	4018	1281	2737	12.65	11.39	1.28	226	0	2737	1742	769
13	3940	1256	2684	12.40	11.17	1.26	222	0	2684	1708	754
14	3862	1231	2631	12.16	10.95	1.23	218	0	2631	1674	739
15	3787	1207	2579	11.92	10.74	1.21	213	0	2579	1642	724
16	3712	1184	2529	11.69	10.53	1.19	209	0	2529	1609	710
17	3640	1160	2479	11.46	10.32	1.16	205	0	2479	1578	696
18	3568	1138	2431	11.24	10.12	1.14	201	0	2431	1547	683
19	3498	1115	2383	11.01	9.92	1.12	197	0	2383	1517	669
20	3430	1094	2336	10.80	9.73	1.09	193	0	2336	1487	656
21	3363	1072	2290	10.59	9.54	1.07	189	0	2290	1458	643
22	3297	1051	2245	10.38	9.35	1.05	186	0	2245	1429	631
23	3232	1030	2201	10.18	9.16	1.03	182	0	2201	1401	618
24	3169	1010	2158	9.98	8.98	1.01	178	0	2158	1374	606
25	3106	990	2116	9.78	8.81	0.99	175	0	2116	1347	594
26-infnty	155322	49524	105798			0.97	8746	0	105798	67338	29714

C4: Open Access at Fertilizer increase by 20%, others constant.

Rangeland Management

Open Access at fertilizer Increase by 20%

Demand		Effort Technology		Growth		Mortality		Fertility Technology	
Scale parameter	1200.00	Effort flexibility	1.60000	Intrinsic rate	0.50000	Intrinsic rate	0.04020	Fertilizer	1.2000
Price flexibility	0.80000	Stock elasticity	0.40000	Environment 1	1.00000	Environment 1	1.00000	Degradation Factor	1.02
Shift parameter	40.00	Consumption rate	0.15000	Environment 2	0.00001	Environment 2	0.00251		

Other Parameters		Net Present Values			
Discount rate	0.02000	Total Willing to Pay	270636.59	Consumer Surplus	119744.07
Price of effort	1.50000	Total Effort Cost	-94307.83	Total Rent	0.00
Initial biomass	900	Net Benefits	176328.76	Producer Surplus	56584.70
				Net Benefits	176328.76

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UNDISCOUNTED VALUES

Year	Biomass	Growth	Mortality	Harvest	Effort	Total Will Pay	Total Effrt Cost	Net Benefits	Price of Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	900	535	353	195	1237	5335	1855	3480	15.21	15.21	1.29	0	0	3480	2367	1113
1	887	527	337	194	1234	5313	1850	3462	15.28	15.28	0.00	0	0	3462	2352	1110
2	884	526	333	193	1233	5308	1849	3458	15.30	15.30	0.00	0	0	3458	2349	1110
3	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2348	1109
4	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2348	1109
5	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
6	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
7	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
8	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
9	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
10	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
11	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
12	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
13	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
14	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
15	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
16	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
17	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
18	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
19	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
20	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
21	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
22	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
23	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
24	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
25	883	525	332	193	1233	5306	1849	3457	15.31	15.31	0.00	0	0	3457	2347	1109
26-infnty	883					270598	94300	176298			0.00	0	0	176298	119718	56580

DISCOUNTED VALUES

Year	Total Will Pay	Total Effrt Cost	Net Benefits	Price Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	5335	1855	3480	15.21	15.21	1.32	0	0	3480	2367	1113
1	5209	1814	3394	14.98	14.98	0.00	0	0	3394	2306	1089
2	5102	1778	3324	14.71	14.71	0.00	0	0	3324	2257	1067
3	5000	1742	3258	14.42	14.42	0.00	0	0	3258	2212	1045
4	4902	1708	3194	14.14	14.14	0.00	0	0	3194	2169	1025
5	4806	1675	3131	13.86	13.86	0.00	0	0	3131	2126	1005
6	4711	1642	3070	13.59	13.59	0.00	0	0	3070	2084	985
7	4619	1610	3009	13.33	13.33	0.00	0	0	3009	2044	966
8	4528	1578	2950	13.06	13.06	0.00	0	0	2950	2004	947
9	4440	1547	2893	12.81	12.81	0.00	0	0	2893	1964	928
10	4353	1517	2836	12.56	12.56	0.00	0	0	2836	1926	910
11	4267	1487	2780	12.31	12.31	0.00	0	0	2780	1888	892
12	4184	1458	2726	12.07	12.07	0.00	0	0	2726	1851	875
13	4102	1429	2672	11.83	11.83	0.00	0	0	2672	1815	858
14	4021	1401	2620	11.60	11.60	0.00	0	0	2620	1779	841
15	3942	1374	2568	11.37	11.37	0.00	0	0	2568	1744	824
16	3865	1347	2518	11.15	11.15	0.00	0	0	2518	1710	808
17	3789	1320	2469	10.93	10.93	0.00	0	0	2469	1676	792
18	3715	1295	2420	10.72	10.72	0.00	0	0	2420	1644	777
19	3642	1269	2373	10.51	10.51	0.00	0	0	2373	1611	762
20	3571	1244	2326	10.30	10.30	0.00	0	0	2326	1580	747
21	3501	1220	2281	10.10	10.10	0.00	0	0	2281	1549	732
22	3432	1196	2236	9.90	9.90	0.00	0	0	2236	1518	718
23	3365	1173	2192	9.71	9.71	0.00	0	0	2192	1489	704
24	3299	1150	2149	9.52	9.52	0.00	0	0	2149	1459	690
25	3234	1127	2107	9.33	9.33	0.00	0	0	2107	1431	676
26-infnty	161704	56352	105352			0.00	0	0	105352	71541	33811

C5: Optimal Management at Degradation of 20%, others constant.

Rangeland Management

Optimal Management at Dagradation of 20%

Demand		Effort Technology		Growth		Mortality		Fertility Technology	
Scale parameter	1200.00	Effort flexibility	1.60000	Intrinsic rate	0.50000	Intrinsic rate	0.04020	Fertilizer	1.0000
Price flexibility	0.80000	Stock elasticity	0.40000	Environment 1	1.00000	Environment 1	1.00000	Degradation Factor	1.22
Shift parameter	40.00	Consumption rate	0.15000	Environment 2	0.00001	Environment 2	0.00251		

Other Parameters		Net Present Values			
Discount rate	0.02000	Total Willing to Pay	230324.24	Consumer Surplus	93697.66
Price of effort	1.50000	Total Effort Cost	-68885.94	Total Rent	26409.07
Initial biomass	900	Net Benefits	161438.30	Producer Surplus	41331.56
				Net Benefits	161438.30

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UNDISCOUNTED VALUES

Year	Biomass	Growth	Mortality	Harvest	Effort	Total Will Pay	Total Effrt Cost	Net Benefits	Price of Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	900	446	423	168	972	4899	1457	3441	16.79	13.89	0.91	486	-418	3023	2081	874
1	756	375	247	152	927	4624	1391	3233	17.89	14.64	2.89	494	-78	3156	1905	835
2	732	363	225	149	912	4562	1368	3193	18.15	14.74	3.25	506	-36	3158	1866	821
3	721	358	216	147	905	4533	1358	3175	18.27	14.78	3.41	513	-18	3158	1848	815
4	716	355	212	146	902	4519	1353	3166	18.33	14.80	3.49	516	-9	3157	1839	812
5	713	354	210	146	900	4512	1350	3162	18.36	14.81	3.53	518	-5	3157	1834	810
6	712	353	209	146	899	4508	1348	3160	18.38	14.82	3.55	519	-2	3157	1832	809
7	711	353	208	145	898	4506	1348	3158	18.39	14.82	3.56	519	-1	3157	1831	809
8	711	353	208	145	898	4505	1347	3158	18.39	14.82	3.57	519	-1	3157	1830	808
9	711	353	208	145	898	4505	1347	3157	18.39	14.82	3.57	519	0	3157	1830	808
10	711	353	207	145	898	4504	1347	3157	18.39	14.82	3.57	519	0	3157	1830	808
11	711	353	207	145	898	4504	1347	3157	18.40	14.82	3.57	519	0	3157	1830	808
12	711	353	207	145	898	4504	1347	3157	18.40	14.82	3.57	519	0	3157	1830	808
13	711	353	207	145	898	4504	1347	3157	18.40	14.82	3.57	519	0	3157	1829	808
14	711	353	207	145	898	4504	1347	3157	18.40	14.82	3.57	519	0	3157	1829	808
15	711	353	207	145	898	4504	1347	3157	18.40	14.82	3.57	520	0	3157	1829	808
16	711	353	207	145	898	4504	1347	3157	18.40	14.82	3.57	520	0	3157	1829	808
17	711	353	207	145	898	4504	1347	3157	18.40	14.82	3.58	520	0	3157	1829	808
18	711	353	207	145	898	4503	1346	3157	18.40	14.82	3.58	520	0	3157	1829	808
19	711	353	207	145	898	4503	1346	3157	18.40	14.82	3.58	520	0	3157	1829	808
20	711	353	207	145	898	4504	1347	3157	18.40	14.82	3.58	520	0	3157	1829	808
21	711	353	207	145	898	4504	1347	3157	18.40	14.82	3.58	520	0	3157	1829	808
22	711	353	207	145	898	4504	1347	3157	18.39	14.82	3.57	519	0	3157	1830	808
23	711	353	207	145	898	4504	1347	3157	18.39	14.82	3.57	519	0	3157	1830	808
24	711	353	207	145	898	4504	1347	3157	18.40	14.82	3.57	520	0	3157	1829	808
25	711	353	207	145	898	4504	1347	3157	18.40	14.82	3.57	519	0	3157	1829	808
26-infnty	711					229700	68691	161009			3.57	26492	0	161009	93302	41215

DISCOUNTED VALUES

Year	Total Will Pay	Total Effrt Cost	Net Benefits	Price Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	4899	1457	3441	16.79	13.89	0.92	486	-418	3023	2081	874
1	4534	1364	3170	17.54	14.35	2.89	484	-76	3094	1868	818
2	4385	1315	3069	17.44	14.17	3.18	487	-34	3035	1793	789
3	4272	1280	2992	17.22	13.93	3.28	483	-17	2975	1741	768
4	4175	1250	2925	16.93	13.67	3.29	477	-8	2917	1699	750
5	4086	1223	2864	16.63	13.42	3.26	469	-4	2860	1661	734
6	4003	1197	2806	16.32	13.16	3.22	460	-2	2803	1627	718
7	3923	1173	2750	16.01	12.90	3.16	452	-1	2748	1594	704
8	3845	1150	2695	15.70	12.65	3.11	443	-1	2695	1562	690
9	3769	1127	2642	15.39	12.40	3.05	435	0	2642	1531	676
10	3695	1105	2590	15.09	12.16	2.99	426	0	2590	1501	663
11	3623	1083	2539	14.79	11.92	2.93	418	0	2539	1471	650
12	3551	1062	2489	14.50	11.69	2.87	410	0	2489	1443	637
13	3482	1041	2441	14.22	11.46	2.82	402	0	2440	1414	625
14	3413	1021	2393	13.94	11.23	2.76	394	0	2393	1386	612
15	3346	1001	2346	13.67	11.01	2.71	386	0	2346	1359	600
16	3281	981	2300	13.40	10.80	2.66	379	0	2300	1333	589
17	3216	962	2255	13.14	10.58	2.60	371	0	2255	1306	577
18	3153	943	2210	12.88	10.38	2.55	364	0	2210	1281	566
19	3091	924	2167	12.63	10.17	2.50	357	0	2167	1256	555
20	3031	906	2125	12.38	9.97	2.46	350	0	2125	1231	544
21	2972	889	2083	12.14	9.78	2.41	343	0	2083	1207	533
22	2914	871	2042	11.90	9.59	2.36	336	0	2042	1184	523
23	2857	854	2002	11.66	9.40	2.31	329	0	2002	1160	513
24	2800	837	1963	11.44	9.22	2.26	323	0	1963	1137	502
25	2745	821	1924	11.21	9.04	2.22	317	0	1924	1115	493
26-infnty	137264	41049	96216			2.18	15831	0	96216	55755	24629

C6: Open Access at Degradation of 20%, others constant.

Rangeland Management

Open Access at Dagradation of 20%

Demand		Effort Technology		Growth		Mortality		Fertility Technology	
Scale parameter	1200.00	Effort flexibility	1.60000	Intrinsic rate	0.50000	Intrinsic rate	0.04020	Fertilizer	1.0000
Price flexibility	0.80000	Stock elasticity	0.40000	Environment 1	1.00000	Environment 1	1.00000	Degradation Factor	1.22
Shift parameter	40.00	Consumption rate	0.15000	Environment 2	0.00001	Environment 2	0.00251		

Other Parameters		Net Present Values			
Discount rate	0.02000	Total Willing to Pay	246582.85	Consumer Surplus	104036.92
Price of effort	1.50000	Total Effort Cost	-89091.21	Total Rent	0.00
Initial biomass	900	Net Benefits	157491.65	Producer Surplus	53454.72
				Net Benefits	157491.65

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UNDISCOUNTED VALUES

Year	Biomass	Growth	Mortality	Harvest	Effort	Total Will Pay	Total Effrt Cost	Net Benefits	Price of Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	900	446	423	195	1237	5335	1855	3480	15.21	15.21	1.29	0	0	3480	2367	1113
1	728	361	222	175	1192	5021	1788	3233	16.32	16.32	0.00	0	0	3233	2160	1073
2	692	344	193	171	1181	4947	1772	3175	16.60	16.60	0.00	0	0	3175	2112	1063
3	672	334	178	168	1175	4905	1762	3142	16.76	16.76	0.00	0	0	3142	2085	1057
4	660	328	169	167	1171	4877	1756	3121	16.87	16.87	0.00	0	0	3121	2067	1054
5	651	324	164	166	1168	4859	1752	3107	16.94	16.94	0.00	0	0	3107	2055	1051
6	646	321	160	165	1166	4846	1749	3097	16.99	16.99	0.00	0	0	3097	2047	1050
7	641	319	157	164	1165	4837	1747	3090	17.03	17.03	0.00	0	0	3090	2041	1048
8	639	317	156	164	1164	4830	1746	3084	17.05	17.05	0.00	0	0	3084	2037	1048
9	636	316	154	164	1163	4826	1745	3081	17.07	17.07	0.00	0	0	3081	2034	1047
10	635	315	153	163	1163	4822	1744	3078	17.08	17.08	0.00	0	0	3078	2032	1046
11	634	315	153	163	1162	4820	1744	3076	17.09	17.09	0.00	0	0	3076	2030	1046
12	633	314	152	163	1162	4818	1743	3075	17.10	17.10	0.00	0	0	3075	2029	1046
13	632	314	152	163	1162	4816	1743	3073	17.11	17.11	0.00	0	0	3073	2028	1046
14	632	314	151	163	1162	4815	1743	3073	17.11	17.11	0.00	0	0	3073	2027	1046
15	631	314	151	163	1162	4814	1742	3072	17.11	17.11	0.00	0	0	3072	2027	1045
16	631	314	151	163	1162	4814	1742	3072	17.12	17.12	0.00	0	0	3072	2026	1045
17	631	314	151	163	1161	4813	1742	3071	17.12	17.12	0.00	0	0	3071	2026	1045
18	631	313	151	163	1161	4813	1742	3071	17.12	17.12	0.00	0	0	3071	2026	1045
19	631	313	151	163	1161	4813	1742	3071	17.12	17.12	0.00	0	0	3071	2026	1045
20	631	313	151	163	1161	4813	1742	3071	17.12	17.12	0.00	0	0	3071	2026	1045
21	631	313	151	163	1161	4813	1742	3071	17.12	17.12	0.00	0	0	3071	2025	1045
22	631	313	151	163	1161	4813	1742	3071	17.12	17.12	0.00	0	0	3071	2025	1045
23	631	313	151	163	1161	4812	1742	3070	17.12	17.12	0.00	0	0	3070	2025	1045
24	631	313	151	163	1161	4812	1742	3070	17.12	17.12	0.00	0	0	3070	2025	1045
25	631	313	151	163	1161	4812	1742	3070	17.12	17.12	0.00	0	0	3070	2025	1045
26-infnty	631					245430	88838	156592			0.00	0	0	156592	103289	53303

DISCOUNTED VALUES

Year	Total Will Pay	Total Effrt Cost	Net Benefits	Price Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	5335	1855	3480	15.21	15.21	1.32	0	0	3480	2367	1113
1	4923	1753	3170	16.00	16.00	0.00	0	0	3170	2118	1052
2	4755	1703	3052	15.96	15.96	0.00	0	0	3052	2030	1022
3	4622	1661	2961	15.80	15.80	0.00	0	0	2961	1965	996
4	4506	1623	2883	15.58	15.58	0.00	0	0	2883	1910	974
5	4401	1587	2814	15.34	15.34	0.00	0	0	2814	1862	952
6	4303	1553	2750	15.09	15.09	0.00	0	0	2750	1818	932
7	4211	1521	2690	14.82	14.82	0.00	0	0	2690	1777	913
8	4123	1490	2633	14.55	14.55	0.00	0	0	2633	1738	894
9	4038	1460	2578	14.28	14.28	0.00	0	0	2578	1702	876
10	3956	1431	2525	14.02	14.02	0.00	0	0	2525	1667	858
11	3876	1402	2474	13.75	13.75	0.00	0	0	2474	1633	841
12	3799	1374	2424	13.48	13.48	0.00	0	0	2424	1600	825
13	3723	1347	2376	13.22	13.22	0.00	0	0	2376	1568	808
14	3649	1321	2329	12.97	12.97	0.00	0	0	2329	1536	792
15	3577	1295	2283	12.72	12.72	0.00	0	0	2283	1506	777
16	3507	1269	2238	12.47	12.47	0.00	0	0	2238	1476	761
17	3438	1244	2193	12.23	12.23	0.00	0	0	2193	1447	747
18	3370	1220	2150	11.99	11.99	0.00	0	0	2150	1418	732
19	3304	1196	2108	11.75	11.75	0.00	0	0	2108	1390	717
20	3239	1172	2067	11.52	11.52	0.00	0	0	2067	1363	703
21	3175	1149	2026	11.30	11.30	0.00	0	0	2026	1336	690
22	3113	1127	1986	11.08	11.08	0.00	0	0	1986	1310	676
23	3052	1105	1947	10.86	10.86	0.00	0	0	1947	1284	663
24	2992	1083	1909	10.65	10.65	0.00	0	0	1909	1259	650
25	2933	1062	1872	10.44	10.44	0.00	0	0	1872	1234	637
26-infnty	146664	53088	93576			0.00	0	0	93576	61723	31853

C8: Open Access at Efficiency from 0.15 to 0.3, others constant.

C7: Optimal Management at Efficiency from 0.15 to 0.3, others constant.

Rangeland Management

Optimal Management at Efficiency of 0.3

Demand		Effort Technology		Growth		Mortality		Fertility Technology	
Scale parameter	1200.00	Effort flexibility	1.60000	Intrinsic rate	0.50000	Intrinsic rate	0.04020	Fertilizer	1.0000
Price flexibility	0.80000	Stock elasticity	0.40000	Environment 1	1.00000	Environment 1	1.00000	Degradation Factor	1.02
Shift parameter	40.00	Consumption rate	0.30000	Environment 2	0.00001	Environment 2	0.00251		

Other Parameters		Net Present Values			
Discount rate	0.02000	Total Willing to Pay	267470.01	Consumer Surplus	117670.47
Price of effort	1.50000	Total Effort Cost	-36448.64	Total Rent	91481.71
Initial biomass	900	Net Benefits	231021.37	Producer Surplus	21869.18
				Net Benefits	231021.37

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UNDISCOUNTED VALUES

Year	Biomass	Growth	Mortality	Harvest	Effort	Total Will Pay	Total Effrt Cost	Net Benefits	Price of Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	900	446	353	258	637	6200	955	5245	12.59	5.93	2.05	1718	-1100	4144	2954	573
1	735	365	191	218	552	5663	829	4834	14.14	6.10	6.66	1750	-349	4485	2586	497
2	691	343	161	203	514	5450	771	4680	14.82	6.08	8.05	1774	-178	4502	2444	462
3	671	333	148	196	494	5342	741	4601	15.18	6.06	8.74	1785	-97	4504	2371	445
4	660	328	142	192	483	5283	725	4558	15.39	6.05	9.12	1790	-54	4503	2332	435
5	655	325	139	190	477	5250	716	4533	15.50	6.04	9.34	1793	-31	4503	2310	430
6	651	324	137	188	474	5231	711	4520	15.57	6.04	9.46	1795	-17	4502	2298	427
7	650	323	136	188	472	5220	708	4512	15.60	6.04	9.53	1796	-10	4502	2291	425
8	649	322	135	187	471	5214	707	4507	15.63	6.04	9.57	1796	-6	4502	2287	424
9	648	322	135	187	471	5211	706	4505	15.64	6.04	9.59	1797	-3	4501	2285	424
10	648	322	135	187	470	5209	705	4503	15.64	6.04	9.60	1797	-2	4501	2283	423
11	647	322	135	187	470	5208	705	4503	15.65	6.04	9.61	1797	-1	4501	2283	423
12	647	322	135	187	470	5207	705	4502	15.65	6.03	9.61	1797	-1	4501	2282	423
13	647	321	135	187	470	5206	705	4502	15.65	6.03	9.62	1797	0	4501	2282	423
14	647	321	135	187	470	5206	705	4501	15.65	6.03	9.62	1797	0	4501	2282	423
15	647	321	135	187	470	5206	705	4501	15.65	6.03	9.62	1797	0	4501	2281	423
16	647	321	135	187	470	5206	705	4501	15.65	6.03	9.62	1797	0	4501	2281	423
17	647	321	135	187	470	5206	705	4501	15.65	6.03	9.62	1797	0	4501	2282	423
18	647	321	135	187	470	5206	705	4501	15.65	6.03	9.62	1797	0	4501	2281	423
19	647	321	135	187	470	5206	705	4501	15.65	6.03	9.62	1797	0	4501	2281	423
20	647	321	135	187	470	5206	705	4501	15.65	6.03	9.62	1797	0	4501	2281	423
21	647	321	135	187	470	5206	705	4501	15.65	6.03	9.62	1797	0	4501	2281	423
22	647	321	135	187	470	5207	705	4502	15.65	6.04	9.62	1797	0	4501	2282	423
23	647	321	135	187	470	5206	705	4501	15.66	6.03	9.62	1797	0	4501	2281	423
24	647	321	135	187	470	5206	705	4501	15.65	6.03	9.62	1797	0	4501	2281	423
25	647	321	135	187	470	5206	705	4501	15.65	6.03	9.62	1797	0	4501	2281	423
26-infnty	647					265504	35936	229568			9.62	91655	0	229568	116352	21561

DISCOUNTED VALUES

Year	Total Will Pay	Total Effrt Cost	Net Benefits	Price Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	6200	955	5245	12.59	5.93	2.09	1718	-1100	4144	2954	573
1	5552	812	4739	13.86	5.98	6.66	1716	-342	4397	2536	487
2	5239	741	4498	14.25	5.84	7.89	1705	-171	4327	2349	444
3	5034	698	4335	14.31	5.71	8.40	1682	-91	4244	2235	419
4	4880	670	4211	14.21	5.59	8.60	1654	-50	4160	2155	402
5	4755	649	4106	14.04	5.47	8.63	1624	-28	4078	2092	389
6	4645	632	4013	13.82	5.36	8.57	1594	-16	3998	2040	379
7	4545	617	3928	13.58	5.26	8.46	1564	-9	3919	1994	370
8	4450	603	3847	13.34	5.15	8.33	1533	-5	3842	1952	362
9	4360	591	3770	13.08	5.05	8.18	1503	-3	3767	1912	354
10	4273	579	3694	12.83	4.95	8.03	1474	-2	3693	1873	347
11	4188	567	3621	12.59	4.85	7.88	1445	-1	3620	1836	340
12	4106	556	3550	12.34	4.76	7.73	1417	0	3549	1799	333
13	4025	545	3480	12.10	4.67	7.58	1389	0	3480	1764	327
14	3946	534	3412	11.86	4.57	7.44	1362	0	3411	1729	320
15	3868	524	3345	11.63	4.48	7.29	1335	0	3345	1695	314
16	3792	513	3279	11.40	4.40	7.15	1309	0	3279	1662	308
17	3718	503	3215	11.18	4.31	7.01	1283	0	3215	1629	302
18	3645	493	3152	10.96	4.23	6.87	1258	0	3152	1597	296
19	3574	484	3090	10.75	4.14	6.73	1234	0	3090	1566	290
20	3503	474	3029	10.54	4.06	6.60	1209	0	3029	1535	284
21	3435	465	2970	10.33	3.98	6.47	1186	0	2970	1505	279
22	3368	456	2912	10.12	3.90	6.35	1162	0	2912	1476	274
23	3301	447	2854	9.93	3.83	6.22	1140	0	2855	1447	268
24	3237	438	2799	9.73	3.75	6.10	1117	0	2799	1418	263
25	3173	429	2744	9.54	3.68	5.98	1095	0	2744	1391	258
26-infnty	158660	21474	137185			5.86	54771	0	137185	69530	12885

C9: Op
mal Management at a Social Discount from 2% to 25%, others constant.

Rangeland Management

Open Access at Efficiency of 0.3

Demand		Effort Technology		Growth		Mortality		Fertility Technology	
Scale parameter	1200.00	Effort flexibility	1.60000	Intrinsic rate	0.50000	Intrinsic rate	0.04020	Fertilizer	1.0000
Price flexibility	0.80000	Stock elasticity	0.40000	Environment 1	1.00000	Environment 1	1.00000	Degradation Factor	1.02
Shift parameter	40.00	Consumption rate	0.30000	Environment 2	0.00001	Environment 2	0.00251		
Other Parameters		**Net Present Values**							
Discount rate	0.02000	Total Willing to Pay	30730.21	Consumer Surplus	15007.31				
Price of effort	1.50000	Total Effort Cost	-9549.50	Total Rent	443.70				
Initial biomass	900	Net Benefits	21180.71	Producer Surplus	5729.70				
				Net Benefits	21180.71				

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						UNDISCOUNTED VALUES											DISCOUNTED VALUES										
Year	Biomass	Growth	Mortality	Harvest	Effort	Total Will Pay	Total Effrt Cost	Net Benefits	Price of Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus	Total Will Pay	Total Effrt Cost	Net Benefits	Price Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	900	446	353	457	1592	8222	2387	5835	8.36	8.36	1.66	0	0	5835	4402	1432	8222	2387	5835	8.36	8.36	1.70	0	0	5835	4402	1432
1	536	266	84	356	1487	7298	2230	5068	10.03	10.03	0.00	0	0	5068	3730	1338	7155	2186	4969	9.83	9.83	0.00	0	0	4969	3657	1312
2	362	180	37	294	1407	6634	2110	4523	11.49	11.49	0.00	0	0	4523	3257	1266	6376	2029	4348	11.04	11.04	0.00	0	0	4348	3130	1217
3	211	106	15	225	1296	5770	1944	3826	13.81	13.81	0.00	0	0	3826	2659	1167	5438	1832	3605	13.02	13.02	0.00	0	0	3605	2506	1099
4	77	38	4	112	805	3832	1207	2625	21.61	17.30	0.00	480	-331	2293	1420	724	3540	1115	2425	19.96	15.99	0.00	444	-306	2119	1312	669
5	0	0	0	0	0	0	0	0	62.74	62.74	4.30	0	0	0	0	0	0	0	0	56.82	56.82	3.98	0	0	0	0	0
6	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	55.71	55.71	0.00	0	0	0	0	0
7	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	54.62	54.62	0.00	0	0	0	0	0
8	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	53.55	53.55	0.00	0	0	0	0	0
9	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	52.50	52.50	0.00	0	0	0	0	0
10	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	51.47	51.47	0.00	0	0	0	0	0
11	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	50.46	50.46	0.00	0	0	0	0	0
12	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	49.47	49.47	0.00	0	0	0	0	0
13	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	48.50	48.50	0.00	0	0	0	0	0
14	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	47.55	47.55	0.00	0	0	0	0	0
15	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	46.62	46.62	0.00	0	0	0	0	0
16	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	45.70	45.70	0.00	0	0	0	0	0
17	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	44.81	44.81	0.00	0	0	0	0	0
18	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	43.93	43.93	0.00	0	0	0	0	0
19	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	43.07	43.07	0.00	0	0	0	0	0
20	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	42.22	42.22	0.00	0	0	0	0	0
21	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	41.39	41.39	0.00	0	0	0	0	0
22	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	40.58	40.58	0.00	0	0	0	0	0
23	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	39.79	39.79	0.00	0	0	0	0	0
24	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	39.01	39.01	0.00	0	0	0	0	0
25	0	0	0	0	0	0	0	0	62.74	62.74	0.00	0	0	0	0	0	0	0	0	38.24	38.24	0.00	0	0	0	0	0
26-infnty	0					0	0	0			0.00	0	0	0	0	0	0	0	0			0.00	0	0	0	0	0

C9: Optimal Management at a Social Discount from 2% to 25%, others constant.

Rangeland Management

Optimal Management at Discount from 2% to 25%

Demand		Effort Technology		Growth		Mortality		Fertility Technology	
Scale parameter	1200.00	Effort flexibility	1.60000	Intrinsic rate	0.50000	Intrinsic rate	0.04020	Fertilizer	1.0000
Price flexibility	0.80000	Stock elasticity	0.40000	Environment 1	1.00000	Environment 1	1.00000	Degradation Factor	1.02
Shift parameter	40.00	Consumption rate	0.15000	Environment 2	0.00001	Environment 2	0.00251		

Other Parameters		Net Present Values			
Discount rate	0.25000	Total Willing to Pay	24422.72	Consumer Surplus	10359.71
Price of effort	1.50000	Total Effort Cost	-7741.52	Total Rent	1676.58
Initial biomass	900	Net Benefits	16681.20	Producer Surplus	4644.91
				Net Benefits	16681.20

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UNDISCOUNTED VALUES

Year	Biomass	Growth	Mortality	Harvest	Effort	Total Will Pay	Total Effrt Cost	Net Benefits	Price of Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	900	446	353	178	1064	5061	1596	3464	16.18	14.37	1.21	321	-153	3311	2186	958
1	815	404	258	168	1037	4901	1555	3346	16.78	14.81	1.80	330	-44	3302	2083	933
2	793	393	238	165	1027	4854	1541	3313	16.96	14.92	1.97	337	-20	3293	2052	924
3	783	388	229	164	1023	4832	1534	3298	17.04	14.97	2.04	340	-10	3289	2038	920
4	778	386	225	163	1020	4822	1531	3291	17.09	14.99	2.07	342	-5	3286	2031	918
5	776	385	223	163	1019	4817	1529	3288	17.11	15.01	2.09	342	-2	3285	2028	917
6	775	384	222	163	1019	4814	1528	3286	17.12	15.01	2.10	343	-1	3285	2026	917
7	774	384	222	163	1018	4812	1528	3285	17.12	15.01	2.11	343	-1	3284	2025	917
8	774	384	221	163	1018	4812	1527	3284	17.13	15.02	2.11	343	0	3284	2025	916
9	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2025	916
10	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2025	916
11	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
12	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
13	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
14	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
15	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
16	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
17	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
18	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
19	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
20	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
21	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
22	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
23	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
24	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
25	774	384	221	163	1018	4811	1527	3284	17.13	15.02	2.11	343	0	3284	2024	916
26-infnty	774					24055	7635	16420			2.11	1717	0	16420	10122	4581

DISCOUNTED VALUES

Year	Total Will Pay	Total Effrt Cost	Net Benefits	Price Harvest	Marginal Effrt Cost	Marginal User Cost	Total Rent	Total User Cost	Dyn Net Benefits	Consumer Surplus	Producer Surplus
0	5061	1596	3464	16.18	14.37	1.52	321	-153	3311	2186	958
1	3921	1244	2677	13.42	11.85	1.80	264	-35	2642	1666	747
2	3106	986	2120	10.86	9.55	1.57	216	-13	2108	1313	592
3	2474	785	1689	8.73	7.67	1.30	174	-5	1684	1043	471
4	1975	627	1348	7.00	6.14	1.06	140	-2	1346	832	376
5	1578	501	1077	5.61	4.92	0.86	112	-1	1077	665	301
6	1262	401	861	4.49	3.94	0.69	90	0	861	531	240
7	1009	320	689	3.59	3.15	0.55	72	0	689	425	192
8	807	256	551	2.87	2.52	0.44	58	0	551	340	154
9	646	205	441	2.30	2.02	0.35	46	0	441	272	123
10	517	164	353	1.84	1.61	0.28	37	0	353	217	98
11	413	131	282	1.47	1.29	0.23	29	0	282	174	79
12	331	105	226	1.18	1.03	0.18	24	0	226	139	63
13	264	84	181	0.94	0.83	0.15	19	0	181	111	50
14	212	67	144	0.75	0.66	0.12	15	0	144	89	40
15	169	54	116	0.60	0.53	0.09	12	0	116	71	32
16	135	43	92	0.48	0.42	0.07	10	0	92	57	26
17	108	34	74	0.39	0.34	0.06	8	0	74	46	21
18	87	28	59	0.31	0.27	0.05	6	0	59	36	17
19	69	22	47	0.25	0.22	0.04	5	0	47	29	13
20	55	18	38	0.20	0.17	0.03	4	0	38	23	11
21	44	14	30	0.16	0.14	0.02	3	0	30	19	8
22	35	11	24	0.13	0.11	0.02	3	0	24	15	7
23	28	9	19	0.10	0.09	0.02	2	0	19	12	5
24	23	7	16	0.08	0.07	0.01	2	0	16	10	4
25	18	6	12	0.06	0.06	0.01	1	0	12	8	3
26-infnty	73	23	50			0.01	5	0	50	31	14

25%, others constant.