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Counting on uncertainty:
The economic case for community based adaptation in North-East Kenya

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nef (the new economics foundation) is a registered charity founded in 1986 by the leaders of The Other Economic Summit (TOES), which forced issues such as international debt onto the agenda of the G8 summit meetings. It has taken a lead in helping establish new coalitions and organisations such as the Jubilee 2000 debt campaign; the Ethical Trading Initiative; the UK Social Investment Forum; and new ways to measure social and economic well-being.

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Foreword

Climate change has already impacted on innumerable rural communities across Africa, exposing them to increasing hazards and making them more vulnerable.

As this trend increases, so does the likelihood that gains in poverty reduction and development may be reversed, particularly for the most vulnerable communities such as those who depend on arid and semi-arid lands for their livelihoods.

Adapting to these hazards and unknowns becomes increasingly urgent and important to ensure economic growth, peace and security in African nations and, equally importantly, locally sustainable socio-economic and environment development. Effective adaptation requires strengthening the adaptive capacity of those men and women most affected by climate change impacts – supporting their ability to make livelihood decisions which are resilient and to manage risks when faced with an uncertain future. Adaptation is as much about making informed, flexible decisions and diversification as it is about implementing specific adaptation interventions. These are all highly context specific; with no one size fits all solution even at the local level. To realise development which is climate resilient will also require innovation, new systems and institutional arrangements and improved access to information on climate forecasts and risks which rural communities and service providers can utilise meaningfully.

With this growing need for effective adaptation and for efficient use of adaptation and development resources, it is important that adaptation at the local level delivers results which are economically viable in the short and long term. On the other hand, it does not make economic sense to invest in sophisticated economic analysis of every adaptation process and intervention in every locality. A broader but still localised method is needed to value the costs and benefits of adaptation. This study conducted by **nef** (new economics foundation) shows that community based adaptation does pay off across a very wide range of modelled interventions and scenarios, when comparing systematic and planned adaptation to a situation with no support to adaptation. The models are based on learning from the real situation of two communities in Kenya's arid and semi-arid lands (ASALs), county level consultations and an analysis of long term climate projections. This study provides new information and justification for investment in community based adaptation which complements other recent studies on the economics of resilience and the value of pastoral livelihoods as productive and adaptive land use systems.[1]

The study makes a valuable contribution to the evidence base for policy and practical support to community based adaptation in arid and semi-arid lands in Kenya. It also presents a model for economic analysis which can provide results at scale to test a range of possible climate and adaptation scenarios. Written in technical detail, with clear reference to methods, models and findings, the report is timely and useful for policy makers, technical staff, adaptation practitioners and economists working in Kenya's ASALs and beyond, to understand the key messages and how they were derived. A policy brief with the key messages and a technical brief on the methodology have been produced alongside the report.

I am hopeful that the study will promote support for strengthening the empowerment and adaptive capacity of the poorest and most vulnerable communities and thereby contribute to achieving adaptation and resilient development in Africa which responds to the future and uncertain impacts of climate change.

Fiona Percy, Regional Coordinator for the Adaptation Learning Programme, CARE International

Executive summary

The intense debates on the uncertainty of climate change impacts present serious challenges to evidence-based policy and decision-making.

Overview

Climate change impacts are expected to significantly erode part of societies' economic, social and environmental capitals.[2] Possessing the resources to adapt and develop resilient, sustainable livelihoods exist in developed economies but much less so in developing economies. In an environment of competing financial demands and a drive to ensure that every pound invested is maximised, the critical question is whether investing in adaptation to climate change projects is *economically efficient* i.e. whether the benefits they create to societies outweigh their implementation and opportunity costs. And if so, how clear-cut are these benefits given pervasive uncertainties relative to future impacts of climate change?

Economic assessments of climate change adaptation interventions usually concentrate on macro and regional scales. Similarly, adaptation interventions pushed by multilateral donors and agencies focus disproportionately on so-called "hard" adaptation measures, such as infrastructural investment or grand scale productive change, in order to spur developing countries' resilience to current and expected climate change impacts. Without downplaying the potential benefits of investing in macro scale "hard" adaptation, a further question is whether "soft" and bottom-up adaptation measures, notably at community or local levels, can equally constitute an effective response to climate change and a viable alternative or complement to macro-scale top-down interventions; and if yes, to what extent and under which conditions?

Through an analysis of community based adaptation within the framework of the Adaptation Learning Programme (ALP), of which CARE International is the implementer, this study aimed to assess whether investing in community based adaptation is economically efficient and effective – holding all else, i.e. future regional or national scale transformations, equal. To this purpose, two communities in Garissa County, North East Kenya, one pastoral and one agro-pastoral, were consulted to provide case studies within a broader objective to investigate the case for investing in community based adaptation.

Context and methodology

Kenyan arid and semi-arid lands (ASALs) have been under frequent strain as a consequence of droughts and floods linked to climatic transformations induced by global climate change. Particularly adverse impacts are intimately linked to the poor nature of regional and local infrastructures as well as overall lower development levels and lower public investment – if compared to national averages. In short, the "adaptive capacity", both on the short and long run, of Kenyan ASALs is considerably lower to other parts of the country. In addressing this issue a critical policy question relates to whether building adaptive capacity should be done in a top-down fashion, e.g. through macro investment in infrastructure and productive transformation to cope with climate change, or rather in a bottom-up fashion, i.e. by empowering communities to adapt to current and future transformation induced by climate change in a manner which is consistent with local priorities, economic necessities and, not least, social and anthropological structures.

A necessary condition for economic efficiency and effectiveness is that the benefits of an intervention exceed the costs. Consistent with the Stern Review guidelines, this study models the costs and benefits of undertaking "action" by comparing these to a "business-as-usual scenario". Benefits, therefore, include the value of avoided losses. Quantitative analysis combines empirical data with secondary information drawn from other studies and international databases. Through the construction of a systems dynamics model this study forecasts the potential impacts of climate change up to 2030, taking into account multiple scenarios which reflect on uncertainties regarding local impacts of regional and global climatic transformations. This model includes not only *economic returns* under different intervention scenarios but equally *social impacts* (e.g. reciprocity structures and gender equality) as well *ecological impacts* (e.g. key ecosystem services) following a "triple bottom line" approach.

Data collected with communities to understand the theories of change and build subsequent models present a stark reality of climate change impacts and, more prominently, climate variability on communities' ability to cope with disaster occurrence and changes in their long term socio-economic infrastructure. Whilst it was beyond the scope of this study to determine an adaptation strategy, a number of parameters were modelled based on the research methodology and via stakeholder engagement. Two significant components of the adaptation strategy were modelled: first an economic diversification strategy through drought resistant agriculture to support the maintenance of pastoralism through a community based approach; second a direct strengthening of livestock pastoralism using drought resistant agriculture as an adjacent instrument.

It is worth noting the double acronym 'CBA' shared by cost-benefit analysis and community based adaptation. For simplicity, the CBA acronym is used to refer to cost benefit analysis in this study and community based adaptation is not abbreviated.

Key findings

Investing in community based adaptation is a wise investment: its environmental, social and economic benefits outweigh the costs in virtually all modelled scenarios.

The study finds that the full stream of benefits (economic, social and environmental) from investing in community based adaptation under numerous scenarios outweighs the investment costs.

Results were controlled for sensitivity of assumptions, notably of discount rates, and accounted for risk and uncertainty relative to future patterns of climate change in ASALs. **Under the most realistic scenarios, investing $1 in adaptation generates between $1.45 and $3.03 of wealth accruing to the communities. Even when using a high discount rate the costs of intervention were 2.6 times lower on average than the costs of not intervening to address climate change and extreme weather events. This means that if action were not taken the per capita income of communities would fall below $1 a day over the next decade. Taking action by investing in community based adaptation can result in a per capita income of about $2.1 a day, on average.** These results suggest that a big part of climate-related socio-economic losses and costs can be avoided through investment in local interventions. Even in a scenario in which there is no anthropogenic climate change and current trends are extrapolated, benefits outweigh costs.

The World Bank has defined "no regret adaptation" as "adaptation options (or measures) that would be justified under all plausible future scenarios including the absence of manmade climate change". Under this definition funding community based adaptation in Garissa, Kenya, is a "no regret" investment. This study illustrates an **unequivocal economic justification for taking action**, i.e. financing community based adaptation to climate change in Garissa, Kenya.

Policy implications

This study equally suggests that local and regional scale infrastructural investment and productive strategies could significantly magnify the benefits of community based adaptation if designed in a manner which does not undermine the socio-economic livelihoods of communities.

Community based adaptation resilience in the face of uncertainty suggests it is an economically-efficient and well-suited response to climate change

Climate change adaptation interventions are inherently designed based on relative uncertainty to the degree, nature and characteristics of future climate change. This implies that there might not be silver bullet strategies to be extrapolated into the future: indeed a choice made today might result in "mal-adaptation" in the future in case climatic transformations are of different nature compared to expected ones. As such, a flexible approach is required: focus should be less about spurring one specific form of transformation and more about broadening potential directions, i.e. broadening the capacity of communities to respond to change, whatever form change takes.

Incorporate both "hard" and "soft" measures in adaptation policy design to maximise value and impact

"Hard" and "soft" adaptation interventions are often perceived as distinct strategies. Our study suggests that intelligent policy-making should focus on both. While hard adaptation aims to spur productive capacities, it cannot necessarily respond to situations whereby infrastructures, priorities and choices need to be dynamically redefined. This is where knowledge, decision-making processes, capabilities and empowerment become critical and irreplaceable. And all these measures are defined as "soft" rather than "hard" adaptation. Ideally, as in the models in this study, these two aspects should walk hand-in-hand, provided that the communities can set priorities and access the information required to tackle such transformations and make decisions. Nonetheless, "hard" adaptation alone could be doomed to fail in a condition of high uncertainty regarding future conditions.

Economic diversification is not always a solution; interventions need to be thoroughly assessed, require dynamic planning and must be compatible with ecological characteristics

When combining the issue of uncertainty with the question of diversification, policy-makers should focus their efforts on providing sufficient flexibility over time through dynamic planning at appropriate levels. As aforementioned, this is less about spurring one specific rigid form of transformation and more about broadening potential directions. In broad terms, productive diversification is thought to be an essential component of any adaptation strategy. In the case of Kenyan ASALs, some suggest that the focus should be put on shifting from livestock pastoralism to drought resistant agriculture, or even to other higher value added crops. This could provide more potential sources of income and thus constitute a form of insurance for communities when one source of income fails. While diversification is evidently a sensible route it is important to question the appropriate mix between different options as well as the potential conflicts over resources (land, water, etc.) arising from different land use choices. If diversification means a competition over scarce resource use then its sustainability must be questioned. Our findings suggest that the optimal option for Kenyan ASALs could be an enhanced support of livestock pastoralism combined with a modest diversification to drought resistant agriculture. As such, decision-makers should be aware that diversification needs to be carefully assessed so as to be compatible with ecological characteristics, rather than applied "across the board". Similarly, if deciding to strengthen pastoralism, then numerous measures are required to make it economically viable for communities.

Investing in community based adaptation presents numerous "double dividends" for policy makers

By building adaptive capacity, community based adaptation responds to a socio-economic development objective. In our model, a business-as-usual scenario implies that communities will fall under absolute poverty levels (i.e. one dollar a day per capita in purchasing parity prices) as a consequence of adverse climatic conditions and extreme weather events. The latter will also reduce health and educational levels among populations. Investing in adaptation provides additional value by meeting development policy needs as well as adaptation needs. For example, diversification of incomes can be a form of insurance to livestock or crop prices volatility, hence spurring food security. Moreover, income diversification can and should entail a gender dimension, notably through an involvement of women within income generating activities as well as spurring their autonomy and involvement in decision-making processes. Similarly, numerous interventions aiming to spur adaptive capacity, e.g. education, information and health, are closely intertwined with development interventions. As such, strict development interventions and adaptation ones should take into account the numerous "double dividends" – provided that uncertainty is factored within the analysis and design of interventions.

Donors of often concerned with the opportunity cost of investment decisions. When considering the opportunity cost of investing in community based adaptation, this study makes the point that the opportunity cost is virtually zero because investment in community based adaptation is synonymous with good development practice, even if it is assumed that climate change will not take place.

Community based adaptation benefits are likely to be enhanced by national level interventions: coordination between national and local level interventions can enhance community based adaptation benefits

National and provincial adaptation interventions are necessary to increase the economic capabilities of communities and societies in order to support them with the necessary economic and infrastructural resources to deal with climate change impacts. Top-down regional strategies should, insofar as possible, take into account uncertainty and dynamic planning. As aforementioned, the merits of soft adaptation consist in building flexibility within policy choices, thus broadening possibilities. Alternatively, such is not necessarily the case of "hard" top-down interventions – which can often be too rigid in face of uncertainty and thus drive "mal-adaptation". As such, rather than expecting communities to adjust ex post to regional choices, the alternative of embedding ex ante local adaptation into regional and national strategies in a bottom-up fashion could minimize the risks of "mal- adaptation" and respond to populations' priorities and capabilities. While large-scale adaptation aims to provide the material means for resilience (through investment in infrastructure), community-based adaptation ensures these means can be mobilized rationally across time (through knowledge of how to utilize new infrastructural conditions and embed them in social norms and community decision-making).

Adaptation can be viewed as a flexible approach to avoid "mal-adaptation" and the costs associated

While, seemingly, disproportionate attention has been given to grand adaptation schemes, empowering communities and populations to deal with climate change impacts is not only efficient and effective in its own right, but can also guide macro policy making and decisions when building regional and national adaptation strategies. Such bottom-up guidance could well be crucial in order (1) to avoid future "mal-adaptation" thus wasting resources in a financially constrained environment, (2) build strategies which are compatible with local needs and (3) prevent local conflicts over access to scarce resources in the ecologically constrained environment which climate change will create.

Given the range of risks and uncertainties and the participatory principle of community based adaptation, this study finds that social cost benefit analysis is a particularly effective tool at valuing what matters to stakeholders, capturing avoided losses and placing externalities within a decision-making framework.

Introduction

According to current calculations, humanity is currently heading towards the worst Intergovernmental Panel on Climate Change (IPCC) forecasting scenarios; an increase in temperatures of 4 to 6°C by the end of the twenty-first century.[3,4] Even in the wake of the economic recession, greenhouse gas emissions continue to rise.[5]

The general context

The global context: mitigation and adaptation

Since climate change mitigation remains far below requirements and expectations to prevent dangerous interference with the climatic system, societies will probably have to adapt to a certain degree of climate change.[6,7,8]

Climate change will erode countries' economic, social, and environmental capitals.[9] Adaptation – the ability both to cope with disaster occurrence in the short run and socio-economic and infrastructural transformation in the long-run will be crucial.

Developed countries and some 'emerging' economies have the necessary resources to spur their adaptive capacity, but this is often not the case for developing countries. In fact, research indicates higher development levels constitute a protection towards climate change impacts.[10]

Climate change adaptation in developing countries

Although developed countries are almost exclusively responsible for Greenhouse Gas (GHG) accumulation, the areas most adversely impacted by climate change are situated in the developing world, particularly the Tropics and sub-Tropics.[11] As a result, developed countries are said to owe developing ones a 'climate debt'.[12] This makes financing climate change adaptation not solely a responsibility of developing country governments but of developed countries too.

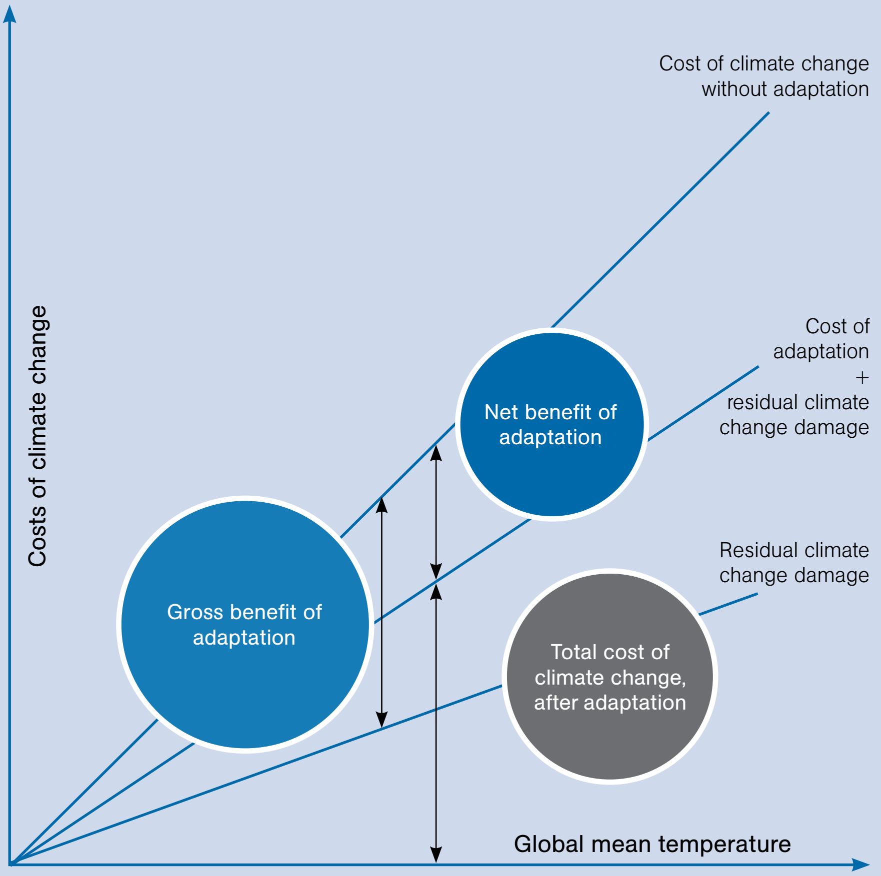
In a context of financial distress and competing demands, not least between a strict classical 'developmental' imperative and climate change adaptation financing, a critical question is to know whether adaptation projects undertaken are *economically efficient* – i.e. whether the benefits they create to societies outweigh their implementation and opportunity costs. And moreover, given the uncertainties surrounding future impacts of climate change, how clear-cut are these benefits?

Appraising adaptation projects in developing countries

There are two economic approaches we can use to evaluate climate change, cost-effectiveness analysis (CEA), and cost-benefit analysis (CBA).[13] Cost-effectiveness analysis compares costs of action to a specific objective (e.g. minimizing water use) to identify the intervention with the lowest economic cost. Cost-benefit analysis is more difficult to conduct because it weighs multiple objectives/impacts for multiple stakeholders, converting all socio-economic and environmental costs and benefits into a common currency. While CEA seeks to answer the question as to *which is the most efficient way of spurring adaptation*, CBA answers this and an additional question, *is investing in adaptation economically efficient?*

This study adopts a CBA approach because it allows us to evaluate multiple benefits, both intended and unintended, across the 'triple bottom-line' (social, economic and environmental outcomes and impacts). It also allows for comparisons across different projects and different countries due to use of a common currency.

Figure 1. *Cost-benefit analysis of climate change adaptation – a graphic overview.*



Note: Gross benefit of adaption = damage avoided. Net benefit of adaption = damage avoided – cost of adaption. Cost of climate change = residual cost of climate damage + cost of adaption.[14]

Numerous analytical frameworks have been proposed to deal with adaptation projects.[15] Figure 1, based upon the Stern Review, shows the most comprehensive of these to this date.[16] It evaluates the benefits of adaptation projects/policies relative to a benchmark/baseline, the latter consisting of the costs of climate change for specific communities/regions/countries or broader geographical areas. This model evaluates the benefits of 'taking action' through adaptation not only to the costs of undertaking a project per se but also to the costs of 'inaction'. Arguably, such is the only manner to capture 'avoided losses' (i.e. encompassed as benefits) in an economic analysis. This study follows Stern's holistic analytical framework, albeit at a micro-economic level.

This framework requires three analytical steps:

1 A socio-economic evaluation of climate changes impacts under a business-as-usual scenario.

2 A definition of adaptation interventions able to mitigate these negative impacts.

3 A socio-economic evaluation of climate change impacts under an adaptation scenario.

CBA is only part of an appraisal process which other considerations need to be factored into; including: the distribution of costs and benefits, socio-economic and environmental equity considerations, as well as less tangible impacts (e.g. the importance of community empowerment).[17] Some forms of adjusted cost-benefit analysis (e.g. Social Return on Investment[18]) can potentially account for some of these elements, but it is important to note that less tangible impacts of adaptation projects may generally require a different assessment, such as multi-criteria appraisals.[19]

Objectives and scope of this study

Commissioned by the Adaptation Learning Programme (ALP), which CARE implements, the aim of this study is to design and conduct an economic analysis of the current and expected costs of climate change impacts experienced in the communities in which ALP operates, in the case of no new adaptation measures. The Adaptation Learning Programme is a five year, four-country, four-donor multi-layered programme aimed at generating learning on community based adaptation to climate change, in order to inform good practice for community based adaptation practitioners as well as local, national and regional policy decisions on adaptation. The framework used by ALP for community based adaptation is presented in Figure 2.

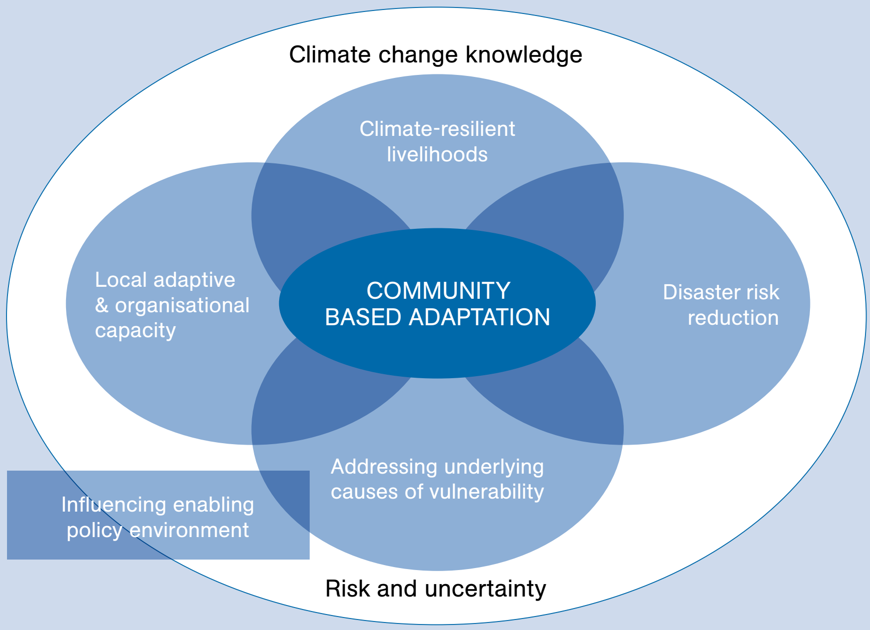
The ALP has a strong focus on community empowerment and a bottom-up approach, notably incorporating both “soft” and “hard” adaptation elements.

Economic assessments of climate change adaptation interventions tend to focus on large-scale macro adaptation programmes. Few studies - if any - have provided evidence on the economic merits of investing in community based adaptation.

This research aims to fill this gap: within the framework of the Adaptation Learning Program (ALP), we seek to assess whether investing in community based adaptation is economically efficient and effective holding all else, i.e. future regional or national scale transformations, equal. The main objectives of this study are (1) to assess the economic efficiency of investing in climate change adaptation in Kenyan Arid and Semi-Arid lands (ASALs), using two communities in the region of Garissa, Kenya as case studies; (2) to provide a *forecastive CBA* which can be replicated to other climatic and socio-economic contexts, notably in Africa.

The study forecasts different climate change and adaptation scenarios to 2030 using case studies from Saka, an agro-pastoral community and Shant’abaq, a pastoral community. The study is aggregated at a district level analysing four main forms of capital: human, social, natural and economic (the latter includes physical and financial forms of capital).

Figure 2. *Scope of the Adaptation Learning Programme.*



Instead of addressing the cost and benefits of an adaptation intervention in an inductive fashion (e.g. downscaling regional economic models), this work follows a deductive, bottom-up, methodology:

- Starting from particular communities and community based interventions, it aims to upscale, insofar as possible, critical empirical findings in order to derive broader policy conclusions and recommendations.

- And secondly, it seeks to launch a debate regarding the extent to which community based adaptation can (a) critically complement and more importantly (b) enhance the effectiveness of macro interventions

To meet these broad objectives the additional components are required:

1 Incorporation of 'soft' social outcomes alongside with 'hard' economic and environmental outcomes;

2 An assessment of risks and uncertainties, which pervades forecasting, through sensitivity analysis;

3 An analysis of multiple competing and/or complementary scenarios in order to minimize the risks of 'mal-investment'.

Indeed, if positive cost-benefit ratios are evidenced for multiple scenarios, both optimistic and pessimistic, then there is a strong mandate for policy intervention.

Structure of the report

This report is structured as follows: Section 1 contextualizes the project, and provides a brief overview of its mains characteristics. Section 2 presents an overview of the methodology used, both for (a) collecting empirical information as well as (b) analysing collected data through economic modelling.
Section 3 presents key findings and results derived from the models, while Section 4 successively addresses replicability, up scaling potentials, and not least the limits of this study. In Section 5, we summarise and conclude by providing recommendations.

1. Context and overview

The region of Garissa can be characterized as highly sensitive in terms of adaptive capacity and resilience to climate change.

Climate change in Kenya and the region of Garissa

From a **climatic** standpoint, expected impacts of atmospheric change in Garissa are likely to be less severe than in other Kenyan regions – if accepting the conclusions of analyses from downscaling of global models.[20] Although overall temperature increases will have an obvious negative effect on Kenyan ASALs, notably altering vegetation cover as well as putting further stress on water resources, a modest increase of projected rainfall is likely to compensate for these factors.[21,22] As such, regional climate models suggest that the length of growing period (LGP) of crops is likely to remain essentially intact on the long run.[23]

However, the likelihood of extreme weather events (floods and droughts) are projected to increase regardless of overall rainfall patterns.[24] Extreme weather events can critically reduce adaptive capacity of communities, destroying physical capital and infrastructures, killing livestock, causing crop failures and increasing vector-borne diseases.[25] Both drought and flood occurrence in Kenya have increased during the past decades. As evidenced by Figure 3 and Table 1, there has been more than simply a trend of reduced rainfall since 1960: there has been the shortening of short and long rainfall periods through an increase of intense rainfall events. This is confirmed by other studies.[26]

Figure 3 and Table 1 present that rainfall variability and drought frequency and have been steadily increasing over the past twenty years. When comparing to Kenyan national averages from an **economic** standpoint, Garissa is characterized

Figure 3. *Trend and variability of annual rainfall in Garissa (1960–2008).*[27]

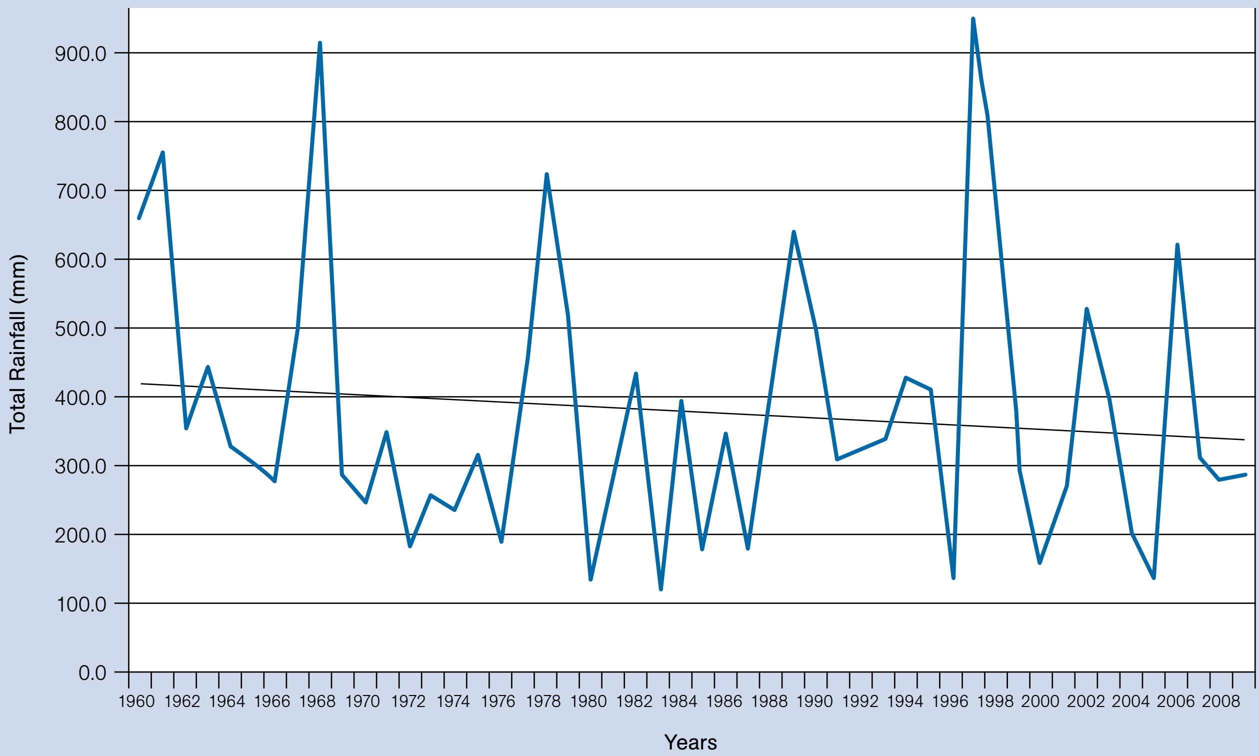


Table 1. *Overview of drought events in Garissa, Marsabit, Samburu and Wajir.*
Note: MD: Moderate; SD: Severe; CD: Calamitous.[28]

Year	Drought decl	Garissa	Marsabit	Samburu	Wajir
1985		CD			SD
1986			MD		SD
1987		CD			CD
1991	x		SD		SD
1992	x			MD	
1993				MD	
1994			MD		SD
1995				MD	
1996	x	CD	CD		
1997	x				
1999	x	MD	CD		SD
2000	x	CD	CD	SD	CD
2001	x	SD			
2004	x	CD		SD	
2005	x	CD			CD
2006	x				
2007			SD		MD
2008		MD			

by: considerably lower GDP per capita; higher absolute and relative poverty rates; lower infrastructural development; lower literacy levels; higher malnutrition levels; lower life expectancy and higher child mortality rates.[29,30] Significantly, the region is overwhelmingly dependent on traditional livestock pastoralism as a source of income and livelihoods. With the notable exceptions of Tana riverine communities, which can be characterized as agro-pastoralist, most communities depend almost exclusively on livestock activities.[31]

Livestock pastoralist activities have been heavily constrained by recurrent extreme weather events, leaving numerous communities without any alternative source of income (except for foreign aid). Water scarcity and vegetation-cover degradation have spurred conflicts over access to resources, undermining livelihoods and, perhaps more crucially, traditional conflict resolution institutional mechanisms – both within and between communities.[32] If pastoralist forms of organisation become obsolete this would be particularly worrying evolution, since it could further reduce the adaptive capacity of communities.[33]

Garissa has one of the highest population growth rates of Kenya, even if we exclude the spectacular inflow of refugees from neighbouring Somalia.[34] Expected population growth, *in tandem* with possible adverse impacts of climate change, will mean additional pressure over natural resources whilst reinforcing current negative trends, creating a ‘vicious cycle’.

Finally, maintenance and lock-in into current forms of livestock pastoralism could constitute a barrier to spur adaptive capacity.[35] Garissa has approximately 12,000 hectares of land suitable for agriculture production, of which only 1100 are currently in use.[36] Lack of education in farming and agriculture as well as capital constraints constitute a significant barrier for communities.[37] Paradoxically, the ability to raise alternative sources of income to support traditional livelihoods could determine the survival of livestock pastoralism itself.[38]

The combination of these factors illustrates the poor adaptive capacity of Garissa communities under current conditions, assuming no policy intervention. The region is facing a number of constraints: insufficient, and even decreasing, financial capital; low human capital and overall human development levels;

Box 1. The Adaptation Learning Programme (ALP)

In 2010 CARE launched the Adaptation Learning Programme aiming to: identify the problems faced by communities in the context of a changing climate; determine potential current and prospective solutions both for communities themselves as well as for the wider region and build a robust community based adaptation strategy, while taking into account broader macro-institutional both regional and national conditions and strategies.

Rather than designing a strategy in a top-down fashion, this five year, four-country, four-donor multi-layered programme heavily focuses on co-production of solutions to climate change impacts, thus putting a significant emphasis on community answers, structures, and decision-making. This rationale among others is rooted in an acceptance that adaptation to climate change encompasses both 'hard' economic elements and 'soft' socio-institutional ones – which are the focus of the following section.

Finally, it is worth noting that while ALP has facilitated analysis of vulnerability, climate risks and current adaptive capacity, the Garissa communities and county have not yet defined an adaptation strategy or plans with ALP's support. As such, this work only accounts for some possible alternative paths and scenarios, which were co-defined with communities, CARE staff and climate scientists.

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Danida
with funding from Austrian Development Cooperation

poorly built environment structures and fragmented markets; resource stress in a context of rising population; the disruption of traditional community management structures and their potential inability to cope with the above transformations.

As such, given the pervasive constraints and specificities of the region there is a strong rationale for investing in climate change adaptation in the region - from a strict development angle alone.[39]

An extensive analysis relative to current and expected impacts of climate change in Kenya and the region of Garissa is available in Technical Appendix 1, which includes exhaustive agro-ecological and topographic patterns.

Background to adaptation interventions

Climate change adaptation planning presents numerous challenges which are often distinct from development planning. These are important both when defining interventions and when evaluating them.

First, uncertainties relative to future climate change impacts on regional, let alone local, scales are significant.[40] Given that any adaptation strategy aims to respond to projected impacts, uncertainties hinder the development of long-run strategy. This requires 'dynamic planning': to establish broad policy lines and refine more precise project/policy components that can be continually revised and if necessary re-defined.[41] Planning flexibility is an essential condition for any successful adaptation strategy.

It is also necessary to distinguish short-run disaster risk reduction (DRR) projects from long-run adaptation planning. While the former is necessarily part of an adaptation strategy, it is the latter which is critical in terms of 'adaptive capacity' of societies.[42]

Adaptation interventions can entail both ‘hard’ and ‘soft’ components.[43] The former broadly refers to large scale infrastructural developments, requiring changes in production and land use systems such as drought/flood tolerant crop varieties, agroforestry or soil conservation. ‘Soft’ adaptation tends to be rooted in communities; education and awareness raising, transformation of management structures (e.g. water managements), institutional incentive schemes, or even build-up of small-scale insurance and financial schemes (e.g. crop or livestock banks).

Viable community based adaptation strategies need to account for possible positive and negative externalities on other communities and eventually entire regions. For instance, transforming production in one community can have negative effects on other communities, and increase vulnerability on a regional scale. This is particularly true of water resource management (e.g. river diversions) or land enclosures, which can notably have adverse impacts on livestock pastoralism.[44] Positive externalities include factors like the multiplier effects of increased income throughout the region.

All of these considerations need to be taken into account both when defining an adaptation strategy for the communities concerned, and when appraising multiple scenarios. Uncertainty in particular requires us to consider multiple adaptation paths given that forecasted climatic conditions might turn out to be different. Thus, adaptation strategies cannot and will not be defined once and for all i.e. without being under constant revision and scrutiny.

2. Methodology

Numerous appraisals and evaluations of climate change adaptation interventions focus on efficiency rather than effectiveness e.g. cost per mosquito net delivered, instead of what mosquito nets achieve in terms of reduced infections and what that means for the livelihoods of communities.

Background

This study aims to do the latter using a holistic economic analysis which considers triple bottom-line impacts, i.e. the economy, the society and the environment.

Following the Stern Review, an economic analysis of climate change interventions should entail: a socio-economic analysis and quantification of climate change impacts under a business as usual scenario; the definition of possible short-run and long-run adaptation/coping strategies and a socio-economic analysis and quantification of climate change impacts under an adaptation scenario (i.e. if coping strategies are implemented).[45] This allows quantifying and measuring the *avoided losses* induced by an intervention, i.e. what would have been lost in a no intervention scenario but is not lost as a result of a given intervention, is attributed as a benefit of the intervention.

While straightforward in principle, complications arise when trying to identify through which methods it is possible to (1) quantify the impacts of climate change on socio-economic system and how they interact, and (2) forecast these impacts into the future, as climate patterns evolve.

The models developed so far by institutions such as the World Bank and the United Nations are tailored to analyse climate change adaptation projects on a regional scale: such is the case of Ricardian models.[46] It is difficult to use these on a local scale; further, the economic analysis these models can provide is only based upon current and forecasted land values under different scenarios. As such, they are not designed to model more qualitative elements of community based interventions, e.g. education and health impacts.

The only consistent model dealing with community based interventions has been the Community-based Sigmoid Exponential Disaster Risk (CSEDR) developed by White and Rorick to analyse the costs and benefits of disaster risk reduction (DRR) interventions.[47] This innovative tool applies solely to DRR interventions and the marginal impacts of DRR measures and which is not applicable to our study.

The unsuitability of both regional models and the CSEDR means that we constructed a model tailored to the impacts we sought to represent in a cost-benefit analysis: (1) triple bottom-line impacts, including the economy, the society and the environment; (2) the interactions between climate evolutions and socio-economic as well as environmental "capitals".

The model, presented subsequently, combines (1) systems dynamics, which allowed us to combine climatic evolutions with socio-economic developments, with (2) the principles of social cost-benefit analysis and social return on investment.

Further information about the models can be found in Technical Appendices 5 and 6.

Methodological approach of the impact analysis

The approach taken by this study merges traditional cost-benefit analysis with the principles of social return on investment (SROI). This study followed a three-pronged approach:[48]

1 Building theories of change through stakeholder engagement with primary and secondary stakeholders.

2 Understanding quantitative social and economic capital evolutions using empirical research with primary stakeholders.

3 Collating robust assumptions through extensive literature reviews and secondary, desk-based research in order to fill the gaps identified in the empirical analysis.

These steps were undertaken by combining empirical research (questionnaires application and stakeholder engagement) with extensive secondary research. We constructed robust theories of change from primary and secondary sources to derive a systematic understanding of the impacts of climate change on the communities in question.

Since interventions have not yet taken place, our analysis deals with hypothetical scenarios. Because of this we incorporate time into our impact analysis, using backward-looking data to forecast our business-as-usual scenario. This approach contrasts with classic "baseline" analyses which do not tend to be dynamic. Our data as well as the theories of change presented incorporate time and evolutions to analyse possible forward-looking developments.

Building the theories of change

A theory of change defines the building blocks required to bring about a given long-term goal. This set of connected building blocks – interchangeably referred to as outcomes, results, accomplishments, or preconditions – can be described in terms of a map or pathway illustrating the change process.[49] A comprehensive theory of change is particularly helpful for developing a framework for measuring what matters, identifying unintended consequences, accounting for negative change, and therefore understanding whether a particular intervention is appropriate.

In order to understand the social, economic, and environmental impacts that climate change has had, is having, and will have in the Garissa region, stakeholder engagement was conducted to build theories of change with primary and secondary stakeholders from each of the selected communities, using a selection of techniques. Table 2 presents an overview of the process of engaging stakeholders and key information about those engaged.

The information provided by the stakeholder engagement was complemented by the ALP's Climate Vulnerability and Capacity Analysis (CVCA) for Saka and Shant'abaq. In the context of Garissa, the CVCA is conducted to establish community priorities and current coping strategies to climate variability.[50] Through the CVCA, the community proposes adaptation/coping strategies and ALP maps these against climate data and analyses their feasibility in terms of financial costs, technical input needed, effect on gender responsibilities and relations amongst other feasibility elements. Additional strategies can be proposed to communities through involvement of local government, local organizations and other technical experts. See Technical Appendices 3 and 4 for results of CVCA.

While social, economic and, to a lesser extent, environmental theories of change were determined through qualitative primary engagement, the climatic theory of change was developed through an extensive literature review which included downscaled data of north-eastern Kenya and the Garissa region, as presented in Technical Appendix 1.

Understanding the quantitative social and economic capital evolutions

The second prong of the methodology involved conducting empirical research with a representative sample of each community in order to understand and value how their economic and social situations have evolved over time. In order to help

Table 2. *Stakeholder engagement summary June 2011.*

Community	Stakeholder	Method of engagement
Saka – Agropastoral	Men: 14 Women: 9	Focus group of 1.5 hour in duration. Questions asked about key changes during and not during drought including: • Daily routine and how this has changed • Community and collective structures of decision-making • Economic production patterns and the future of pastoralism • Gender relations (perceptions of each gender) • Migration patterns • Perceptions of climate change • Perceptions of adaptation (i.e. what should be done) • Decision-making for women: extent to which involved at family and community level • Roles/responsibilities within the family/community • Relationships: whether these had been affected • Perceptions on the future
Shant'abaq – Pastoral	Men: 11 Women: 8	
Kenyan Meteorological Department	Dr. Samuel Marigi - Kenya Meteorological Department Prof. Francis Mutua - Department of Meteorology, University of Nairobi Dr. Wilson Gitau - IGAD Climate Prediction and Applications Centre (ICPAC)/ Department of Meteorology, University of Nairobi	Meeting to understand Kenyan climate scientists' theoretical and empirical knowledge. Scientists of the Kenyan Meteorological Department and University of Nairobi kindly presented and shared collected data on rainfall and temperature patterns evolutions. They also analyzed their perceptions of climate change socio-economic impacts in Garissa as well as possible adaptation strategies to cope with negative climatic developments. Their knowledge has been invaluable in determining localized impacts, which are hardly addressed in global models or regional downscaling ones.
Local Government Garissa	Bashir Muhumed- Ministry of Agriculture District Agricultural Officer, Garissa District.	Meeting to understand the local government perception of changes to pastoralist communities caused as a result of climate change and activities that need to be taken to support community based adaptation.
Climate Change Directorate, Nairobi	Mr. Stephen Kinguyu- Climate Change Secretariat, Ministry of Environment and Mineral Resources Eng Moses- Omedi, Head of CC Secretariat, MEMR	Meeting to understand the national policy context and national government position on climate change in Kenya.
Care	ALP team in Garissa	Multiple meetings and discussions to verify theories of change and explore potential adaptation scenarios.

with valuation of gender equality, a focus group with women was conducted and a willingness-to-pay technique was employed.

It is important to note that this study focuses on the central economy in the communities, which is livestock production. It is concerned with how the central economy reacts when faced with recurrent and/or prolonged climate extremes/shocks and the consequent nature of the relationship of climate change with wider social and less tangible impacts.

Empirical research was conducted by administering a 15-minute socio-economic questionnaire to households within the communities. Twenty households were surveyed in Saka and 16 households were surveyed in Shant'abaq, representing approximately 10 per cent of households within the central confines of the communities. The samples were constructed through random selection of households in different areas of the community, so as to achieve the best representation possible. It is interesting to note that saturation was achieved within the sample surveyed.

The socio-economic questionnaire is presented in Technical Appendix 2 and covers questions from the central economy (livestock) to wider local economic activity to social outcomes such as community structures and gender equality for women.

Whilst most of the valuation of outcomes was derived using a benefit transfer technique from existing studies, this was deemed inappropriate when valuing outcomes about gender equality for women. Amongst ALP's aims is to tackle gender equality within communities and to promote rights for women. Stakeholder engagement revealed gender equality to be one of the key outcomes for women in the communities but there is a lack of existing secondary literature valuing these outcomes for women. We therefore conducted a simple willingness-to-pay exercise with a group of women from each community, as part of this study and to appropriately valuing the outcomes that matter to them.

Collating robust assumptions for multiple scenarios, valuation of costs and benefits, and construction of cost-benefit models through extensive literature reviews and secondary, research.
Constructing economic models to simulate the costs and benefits of action vs. inaction of adaptation to climate change requires extensive literature reviews and use of secondary data. Primary research with the pastoralist communities in Saka and Shant'abaq provided this study with strong socio-economic data with which to analyse trends and build assumptions. Assumptions are presented in Technical Appendices 5, 6 and 7.

Methodological approach of the quantitative analysis

Analysing the costs associated with climate change on a local scale is a significantly different to on a regional or continental scale. The estimation of local impacts of climate change is an inherently uncertain exercise, notably due to micro-climate patterns and (2) local socio-economic impact studies are significantly less documented and tend to be context-specific.[51] Downscaling economic figures from regional assessments to a local level (i.e. transposing economic costs derived from global or regional Computable General Equilibrium (CGE) models) would be speculative and imprecise so we adopted a bottom-up approach. Our methodology is inherently empirical: it builds upon local findings in order to derive both the costs of climate change as well as the possible socio-economic impacts of adaptation on a community-scale.

The model construction consisted of two distinct steps:
1 The construction of a business as usual scenario model
2 The construction of the adaptation model

Adaptation consists of an alternative scenario *within* the business as usual model. So the output of this exercise is a fusion of both models, since the *net benefits* of climate change adaptation are represented by the difference between the socio-economic capital evolution in an adaptation scenario (net of upfront investment costs) and the socio-economic capital evolution under business- as-usual. Also, modelling the impacts of adaptation is essentially a transposition exercise: after identifying coping strategies, mitigation capacity to reverse climate change impacts need to be superposed on the business-as-usual model.

This section presents the methodology used to build the business as usual and adaptation scenarios by presenting the assumptions in:

- Building a model of climatic capital evolution
- Building a model of socio-economic capital evolution
- Determining the relationships between the models
- Presenting the logical framework, model and sub-models

Building climate scenarios: forecasting climatic evolution
The costs associated with business as usual scenarios are intertwined with climate change forecasts, in particular temperature and rainfall patterns. There is high level of uncertainty regarding these, especially when focusing on a local geographical scale. As evidenced in Technical Appendix 1, there are multiple global scenarios as per the IPCC and there is also high uncertainty regarding linkages of these scenarios with global and regional rainfall patterns

evolutions.[52] One such example is that El Niño Southern Oscillation (ENSO) effects are not considered in regional models. Because of this and because of uncertainty of climate models in general, we considered it necessary to include numerous sub-scenarios as part of this study up to 2030.

- The first two scenarios were extracted from downscaling global models and are based upon existing literature.[53] The scenarios were calibrated to global emission scenarios of the IPCC: A2 and B1.[54]

- A third scenario builds upon data from the Kenya Meteorological Department. The third scenario differs from the first two insofar as we projected a continuation of observed trends since 1961, most critically of decreasing (rather than slightly increasing) rainfall. Climate impacts are analyzed and modeled in a linear fashion, as it was beyond the scope of this study to model trends in alternative ways.

The above sources are suggested to be the most appropriate ones as per existing literature, see Technical Appendix 1. Climatic evolution of temperature and rainfall were forecasted using data from the above three scenarios, presented in Technical Appendix 7.

Forecasting extreme weather events is complex: droughts and floods are inherently uncertain events. We modelled the likelihood of droughts using binomial probabilities and randomized selection based on previous occurrence (1980-2010) in terms of frequency and magnitude. The figures obtained do not aim to predict droughts but to provide a scenario founded with yearly probability of occurrence. Sweeney et al forecast extreme rain events as a percentage of total rainfall, figures which were used in our analysis.[55]

Building socio-economic scenarios: social and economic capital evolutions

For an impact analysis of socio-economic patterns we used two resources:

1 CVCA results from ALP's work with Saka and Shant'abaq
2 Empirical research from socio-economic questionnaires with the communities

While CVCA results are more detailed in their impact analyses, the data is nonetheless "static". The socio-economic questionnaire aimed to grasp, dynamic tendencies as far as possible (see Technical Appendix 2 for the questionnaire). Impacts considered were the following:

1 Evolution of economic capital: mainly focusing on livestock capital flows and stocks, but equally considering other income sources

2 Evolution of financial capital (i.e. savings, debts).

3 Evolution of multiplier effects: the indicator used for that purpose was net spending at the local shops.

4 Evolution of community autonomy and external dependence: in such case, dependence on food relief was used.

5 Evolution of human capital: education and health impacts of climate change, notably comparing regular climatic conditions with years characterized by extreme weather events occurrence.

6 Evolution of social capital: we first looked at reciprocity, redistribution structures and broader economic participation to community life. Second, we used travel periods for livestock activities as an indicator for social participation either to community decision-making or to family life.

7 Analysis of gender impacts: the quantitative indicator used for this purpose was women nutrition and nutritional change.

Bringing the two together: climatic and socio-economic capital evolutions

It was necessary to understand the relationship between the variables of climatic evolutions and socio-economic evolutions, not least because data was collected based on only two static points in time (pre and post drought). Determining the relationships between the variables and capital evolutions consisted of two steps:

1. Determining the relationship of climate change evolution on economic capital (i.e. livestock more specifically);

2. Determining the relationship between economic capital and social capital.

The relationships were ascertained using the following:

- Ordinary Least Squares (OLS) regression: a statistical test to test the significance of the relationship between climate change and decreased socio-economic capital in order to derive coefficients (i.e. to what extent and by how much socio-economic capital changes as a consequence of climate evolutions);

- An extrapolative forward and backwards-looking econometric function in which socio-economic capital evolves with climate change, i.e. their parallel change evolves at a pace/level of co-integration of previously established relationships through the OLS regression in a dynamic fashion.

The economic and financial models place a strong emphasis on revenues from livestock pastoralism. Other activities such as small business are important, nonetheless, livestock and livestock products revenues are the ones that *determine* to a large extent the overall economic patterns of communities. Additional income sources crucially *depend* on the multiplier effects arising from livestock. This is largely due to current infrastructural conditions and to the relatively high value-added marketed nature of the livestock sector – both on community and regional scales.

The following factors were also taken into consideration in the construction of the models:

- Ecological indicators such as impacts on natural resources and/or biodiversity were based upon secondary research. Values were transposed through estimations of "benefit transfer", due to insufficient empirical data[56]

- All the data gathered was used to formulate a range of composite indicators to allow impacts to be modelled using different scenarios

- Once indicators were created, the impacts were valued. The valuation process was based upon two approaches:

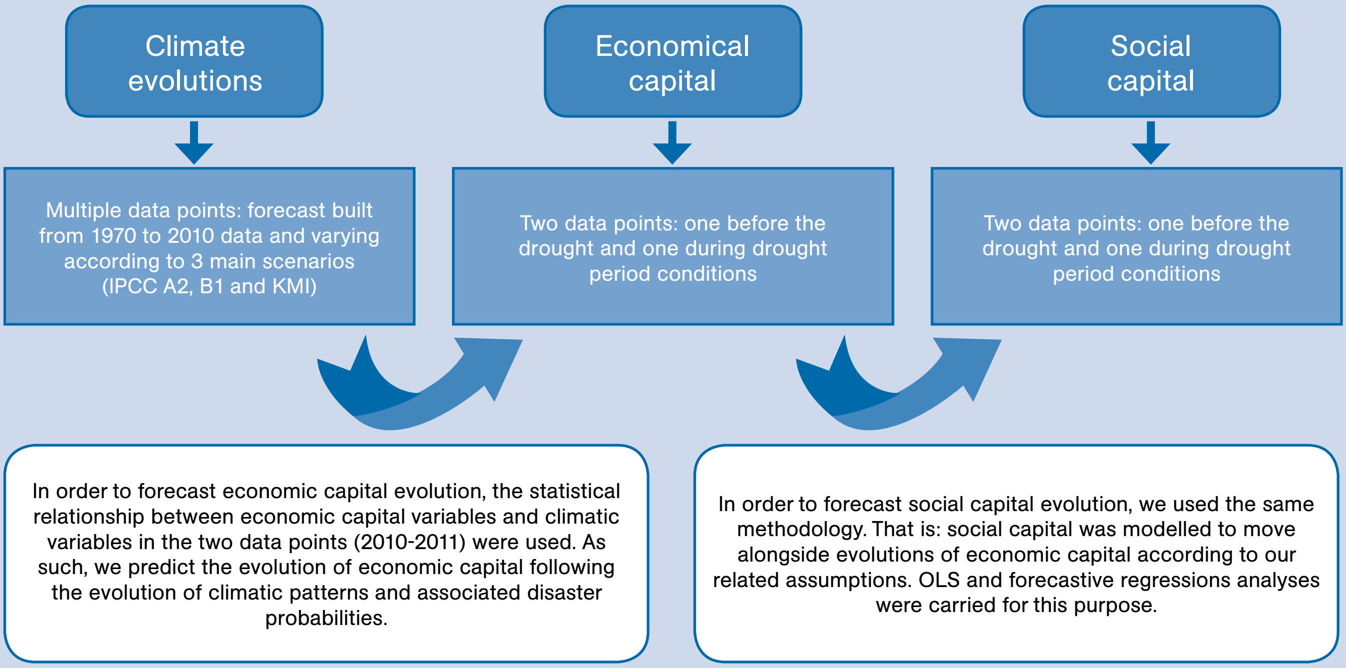
- Calibrated benefit transfer, transposing values obtained in other studies (e.g. valuation of "time") to ALP sites by adjusting figures to account for local specificities - either through the use of purchasing power parity (PPP) or by calibrating monetary value to local income levels

- The employment of willingness-to-pay (WTP) exercises. WTP permits the capture of less tangible and more context-specific values. In this research it allowed us to capture how women within the communities valued their changing roles and participation in decision-making and economic life.

- All market prices were translated to shadow prices, when possible, in order to reflect for the actual economic resources used (as per CBA guidelines and standard practices).

Final costs and benefits are expressed in USD – and adjusted to PPP (purchasing power parity). This notably allows donors draw meaningful comparisons of the return on investment of different interventions across different geographical regions.

Figure 4. *A graphic explanation of the overall modelling process.*



It is worth noting that economic capital encompasses as well environmental capital since the latter directly impacts on the former in terms of decrease of ecosystem services.[57]

The business-as-usual scenario entails some degree of adaptation and development regardless of external interventions or support. This is because communities have already established some forms of coping strategies, as evidenced by CVCA results (see Technical Appendices 3 and 4). We also assume additional adaptation based on regeneration capacity of livestock capital according to current community savings. Multiple business-as-usual scenarios were constructed based on different degrees and scales of autonomous regeneration capacity.

Estimating the impacts of community based adaptation

Modelling the impacts of adaptation requires identifying adaptation strategies, their capacity to reverse climate change impacts and view this alongside the business-as-usual model.

Two key elements are required for analysis: the **initial input cost** of adaptation interventions and the **impact potential** of selected adaptation activities. While precise adaptation strategies have yet to be defined for the communities Garissa we were able to derive numerous adaptation scenarios using information obtained from the CVCA, stakeholder engagement and academic conversations and literature.

A further analytical distinction between disaster risk reduction (DRR) /short-term adaptation measures and long term investment in adaptation is required when estimating the imapcts of community based adaptation.

While both were included in our analysis it is critical to note that the latter is more complex to define than the former. Indeed, long term adaptation aims to tackle, among others, productive transformation which constitutes a non-marginal development. As such, both conceptual and modelling assumptions sitting behind it are far more considerable and the results should therefore be treated with caution. It is evident that both short-term measures and DRR walk hand-in-hand with long-term adaptation: while both are different, the one requires the other. The distinction has been made for the sake of clarity in the presentation of this study.

DRR programme activities that were modelled include:

1 Education, awareness promotion and creation of community based DRR committees

2 Spread of early warning systems

3 Erection of dykes (for riverside communities)

4 Fencing of houses

5 Creation of community based banking/insurance schemes in order to "smoothen" cycles (i.e. capital decrease) arising from disaster occurrence. It is worth noting, however, that funding capacity of such insurance or banking schemes are dependent on overall financial capacity of communities, and thus on long-run income flow, which brings about the issue of longer-run productive investment.

Adaptation programme activities modelled in this analysis encompass:

1 Income diversification through the promotion of:

- Fodder production thus shifting part of livestock pastoralist to livestock farming;

- Small-scale agricultural production, mostly through cultivation of drought resistant crops in order to minimize "mal-investment" risks;

- Small business development (e.g. handcraft)

2 Investment in animal health, including access to providers.

3 Investment in human health to mitigate potential adverse impacts. This includes vector-borne diseases.

The above elements entail additional components such as irrigation works, either from the River Tana (for riverside communities) or through drip irrigation, whilst using water from the Merti aquifer – where possible and within the aquifer's sustainability regeneration boundaries.[58] Income diversification encompasses elements such as increasing market access and value chain management as well as promoting participation of women in new activities, such as small business, whilst, spurring gender equality through increased participation of women in income generation. Lastly, reduction of adverse impacts and related "avoided costs" were modelled to have an impact on both human capitals (health and education) and social capital.

Logical framework for economic costs and benefits of community based adaptation

An overall logical framework matrix as per European Commission's guidelines presents broad outcomes and expected impacts considered in this analysis in Table 3.

Costing the investment in community based adaptation

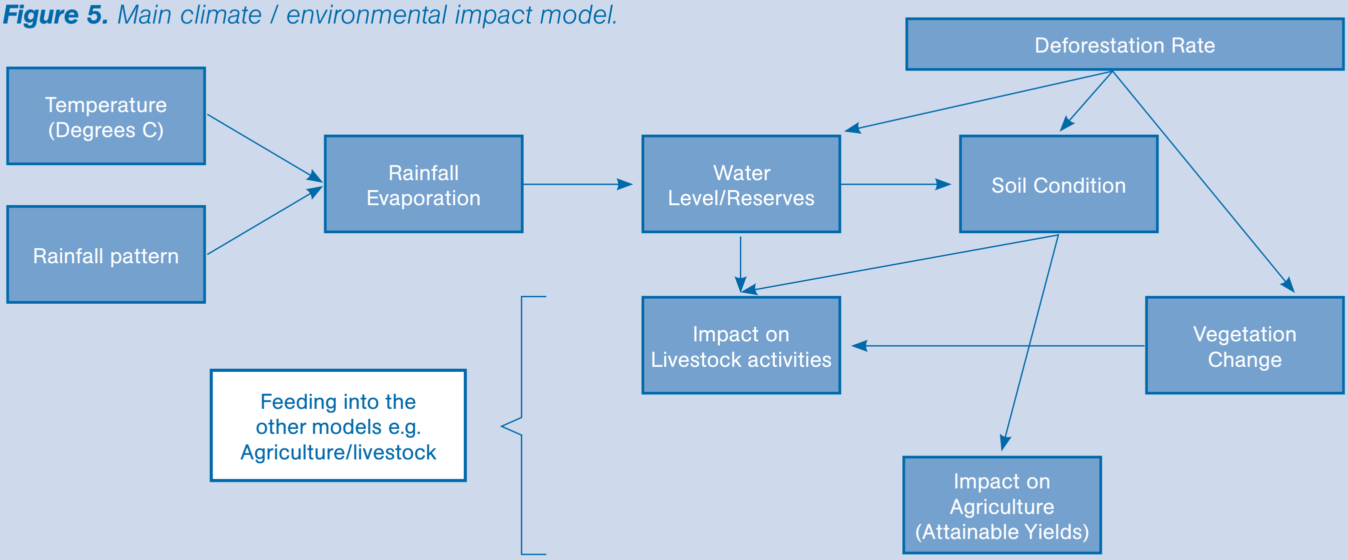
To model the costs of financing adaptation activities the overall budget of ALP over a five-year period was used. Ascertaining accurate costs for an adaptation strategy that is not yet determined is challenging, and ALP's activities and objectives were deemed sufficient for modelling the costs of the selected adaptation strategies.

It is essential to note that financial costs do not represent economic costs. Costing a program from an economic rather than strictly financial standpoint needs to account for the full stream of resources and inputs used: which financial (market) costs fail to do accurately.[59] As such, the use of shadow pricing is considered best practice in cost benefit analysis in order to derive economic costs and benefits.[60] When possible, shadow price adjustment was factored within our analysis.

Table 3. *Logical framework for economic analysis of community based adaptation.*

Project Description	Indicators	Means Of Verification	Assumptions
Overall objectives/outcomes: 1. Increase adaptive capacity of communities 2. Ensure economic sustainability 3. Ensure social sustainability	Overall income generated (including savings, debt and fixed capital) Multiplier effects through the community Overall impacts on social capital, i.e. community cohesion Overall impacts on human capital (health and education)	Primary data collection and analysis Forecasting analysis	n/a
Purposes: (1) Reduce dependence of communities' livelihoods on livestock pastoralism or (2) Re-strengthen pastoralism (2) Spur income diversification (3) Promote productive activities which are compatible with expected climate change impacts (4) Smooth cycles provoked by external shocks (i.e. disasters)	Percentage income depending on livestock pastoralism Attainable yields taking into account forecasted climate change impacts on the LGP	Primary data collection and analysis Extant literature review on forecasted LGP and attainable yields per crop in arid and semi-arid lands	(1) Community can ensure economic viability without further 'external' assistance (2) Economic diversification/risk spreading is a viable adaptation strategy (3) Economic diversification leads to social sustainability (4) Environmental/resource sustainability is ensured
Outputs (Results): (1) Increased agricultural production (2) Increased livestock farming production (3) Reduce vulnerability to disasters	Mean attainable yields per hectare per crop Attainable livestock productivity Infrastructure and capital destroyed by extreme weather events Human costs of disasters	Literature / statistics on mean attainable yields in Africa arid and semi-arid lands per crop Literature / statistics on attainable livestock productivity in African arid and semi arid lands	(1) Communities can culturally cope with a transition from livestock pastoralism to agriculture and induced social/anthropologic transformation (2) Access to markets is ensured
Inputs (Activities): (1) Agricultural education / training (2) Irrigation infrastructure (3) Crop provision for agriculture and fodder (4) Other agricultural requirements (fertilizers, etc.) (5) Livestock veterinary interventions (6) Supplementary feeding for livestock (7) Destocking (emergency livestock purchase of weak animals) (8) Creation of community based bank/ insurance scheme (9) Erection of Dykes (10) Fencing of houses (11) Training community in DRR and creating a DRR committee (12) Health access (livestock and human)	Investment in infrastructure required (2010 USD) Wages and overall programme management (2010 USD) Human capital/time input (expressed in 2010 USD) No of animals saved Income increase during drought No of productive investment financed (expressed in no of animals) Costs avoided Population attending	Local capital input prices Local wages adjusted for shadow prices, used as a proxy for opportunity cost of time.	(1) Education and training provide population with the necessary technical skills to become farmers or (2) In case of investment in livestock pastoralism, adaptation measures walk hand-in-hand with access to resources determined either on a regional scale on between communities conflict resolution mechanisms (3) Conflict over land property is resolved within the communities' institutional structures

Figure 5. *Main climate / environmental impact model.*



The choice of discount rate (for a full explanation of discount rates see Section 3) can be controversial (as evidenced by the debate following the publication of the Stern Review) since it strongly determines the outcomes of a CBA. Since we do not wish to enter this debate, results were modeled using three discount rates: 1 per cent, 4 per cent and 8 per cent. Attaining positive cost-benefit ratios in either scenario is synonymous with a very strong case for investing in adaptation measures.

Constructing the main model and sub-models: a quantitative translation of theories of change

The main model presented previously in Figure 4 is composed of numerous sub-models analysing and quantifying critical components of both business-as-usual and adaptation scenarios. Sub-models for climatic, livestock (economic), agricultural (economic), environmental and social capital evolutions are presented in this section.

The direction of the arrow denotes the flow of impact that was modelled in the study. Figure 5 presents an overview of the main climate and agro-ecological model used for determining climate change and adaptation impacts. As illustrated, temperature change and rainfall patterns transformation blend with other phenomena impacting on agro-ecological conditions, such as deforestation.

Figure 6. *Main livestock model.*

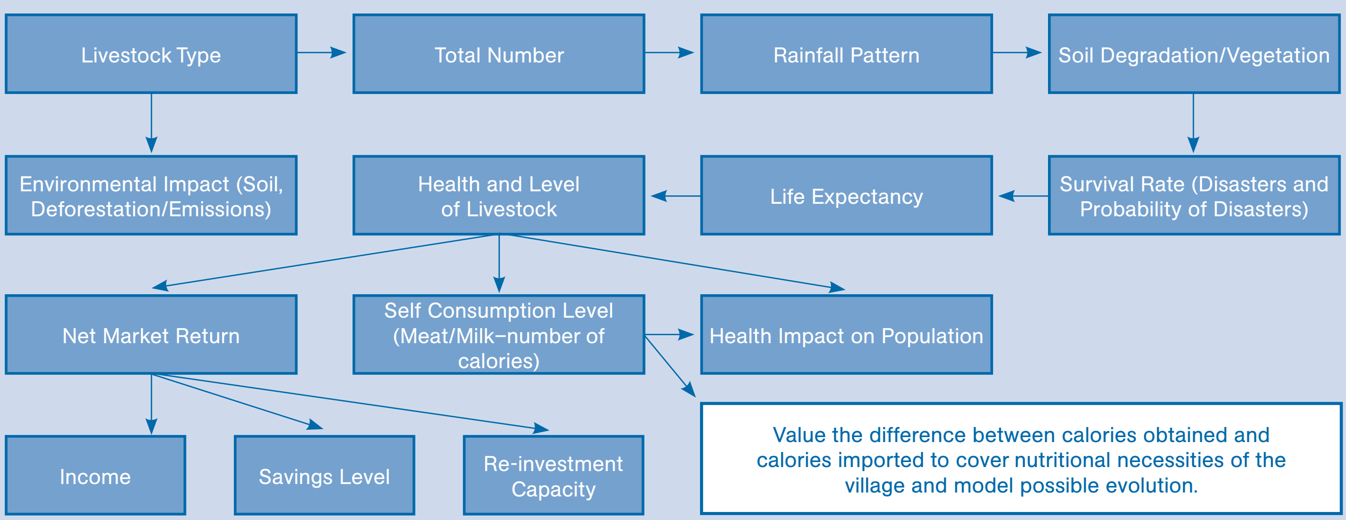


Figure 7. *Main agricultural model.*

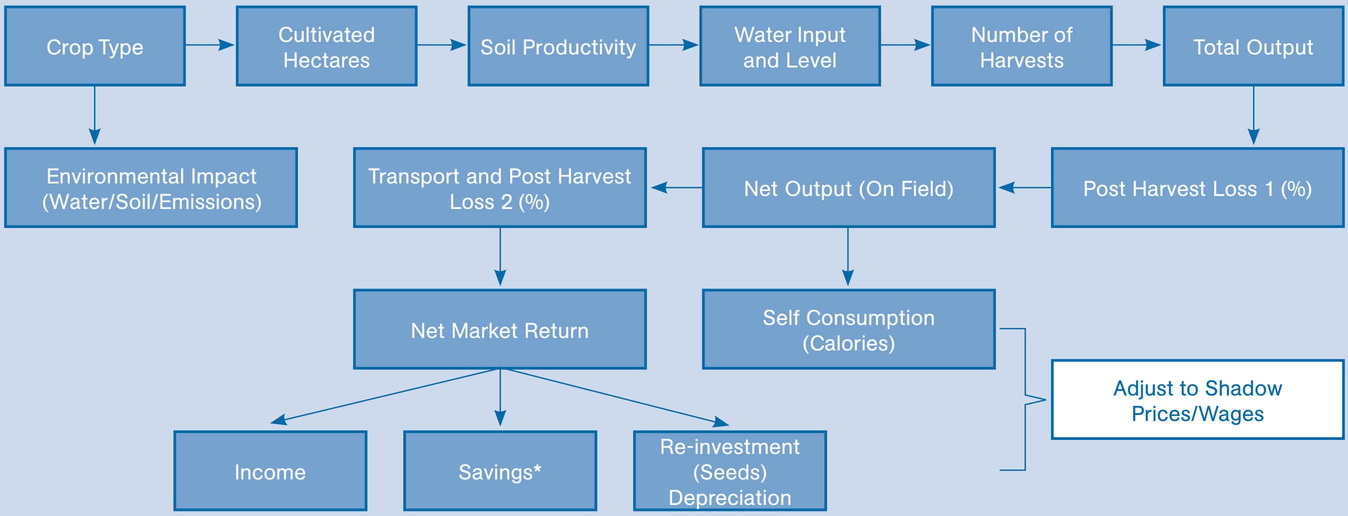


Figure 6 illustrates how livestock capital links back to the climate model, and forth to direct socio-economic impacts. It is worth noting, for instance, that beyond direct impacts of climate change and extreme weather events on health, there are indirect consequences as well: via livestock health and via increase/reduction of overall income. An income reduction or nutritional decrease could hamper potential adaptation on a community level

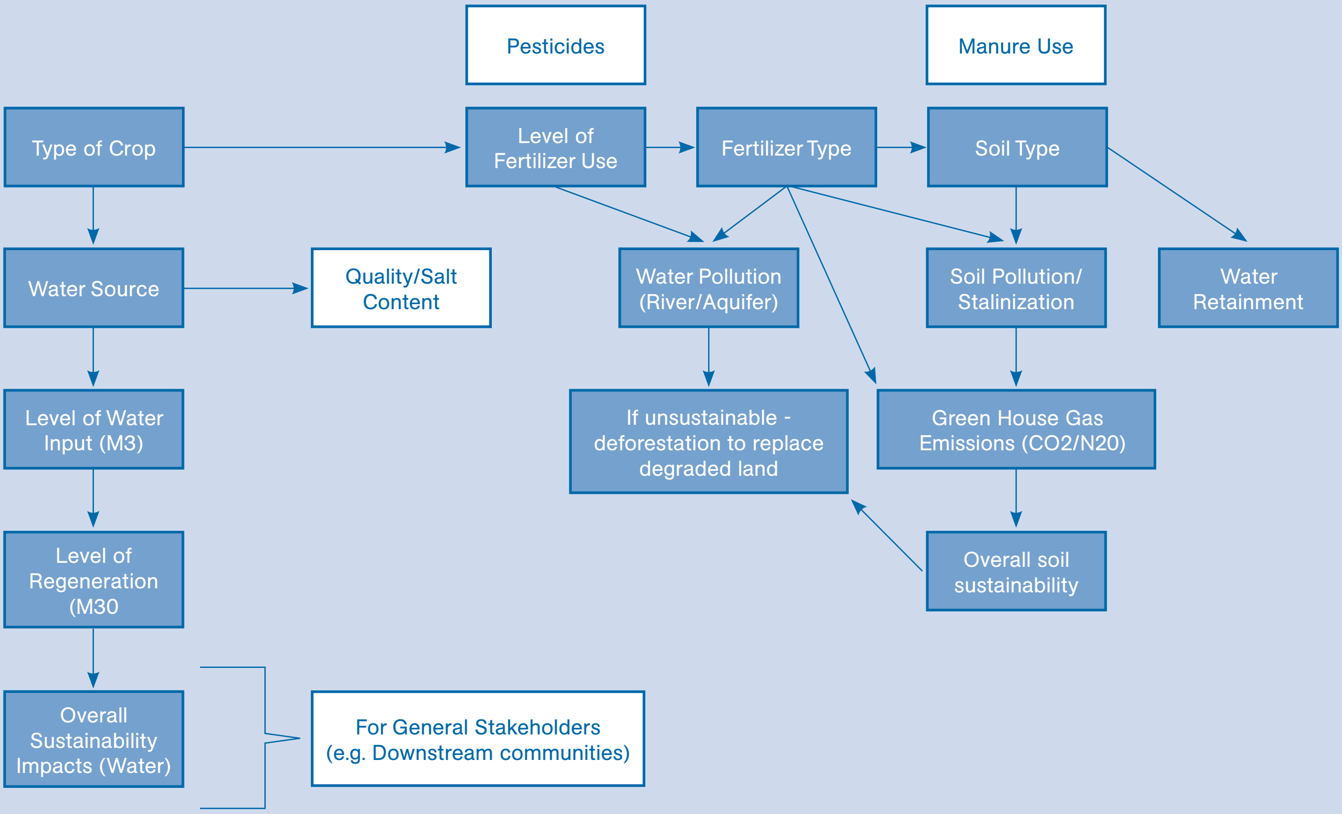
The arrows indicate being "determined by" e.g. savings level is determined by net market income. So it is not livestock type which determines rainfall pattern but the total number of livestock blending with rainfall patterns that determine survival rate, sustainability etc. In turn, these determine economic and financial patterns of the communities – and their evolution. Deforestation rate is not a direct climatic impact but is included as an exogenous variable respectively magnifying or limiting climate impacts on overall water availability, land aridity and productive structures. Similarly vegetation cover can influence micro-climatic patterns and is therefore a determinant component when dealing with local scale developments.[61]

A crop model presented in Figure 7 was used to appraise diversification possibilities, depending on numerous resource constraints (e.g. aridity level, soil conditions, water availability etc.). These are evidently intertwined. Additional elements taken into account in order to determine potential net economic returns included post-harvest losses – since these are a pervasive characteristic of developing countries' agricultural sectors. Finally, capital depreciation was taken into account: this can take the form of re-investment necessities in infrastructure (e.g. for irrigation) or crops.

Since adaptation measures often aim to constitute a drive towards productive transformation and/or intensification, it is critical to evaluate environmental impacts of different options, which are summarised in Figure 8. Impacts of either livestock or agriculture (including different crop options) need to be factored in order: (1) to assess resource sustainability of specific adaptation options and (2) to include evolution of natural capital, and ecosystem services under different productive ramifications (including for downstream/other communities). Evidently, potential impacts equally depend on *techniques* of production. This means cultivation of the same crop can be carried through in both sustainable and unsustainable manner. This allows differentiation of the conditions of different communities, and therefore possible context-specific options.

Figure 9 presents the theory of change under the current BAU scenario for Saka and Shant'abaq, as developed through the stakeholder engagement. The impacts of increasing climate variability on the social structures, norms and traditions of both communities are stark and pronounced.

Figure 8. *Pollution / environmental impact model.*



There were four key themes emerged from engagement with the community on the social impacts of climate change:

- **Community structure and support:** the extent to which the community is able to support those in need has been significantly impacted due to an increase in need and a reduction in variance of the economic capital of households. It was also reported that traditional structures, such as those regulating the use of pasture at different times in the year, are no longer being respected as a result of a breakdown of the collective responsibility and community approach to livelihoods.

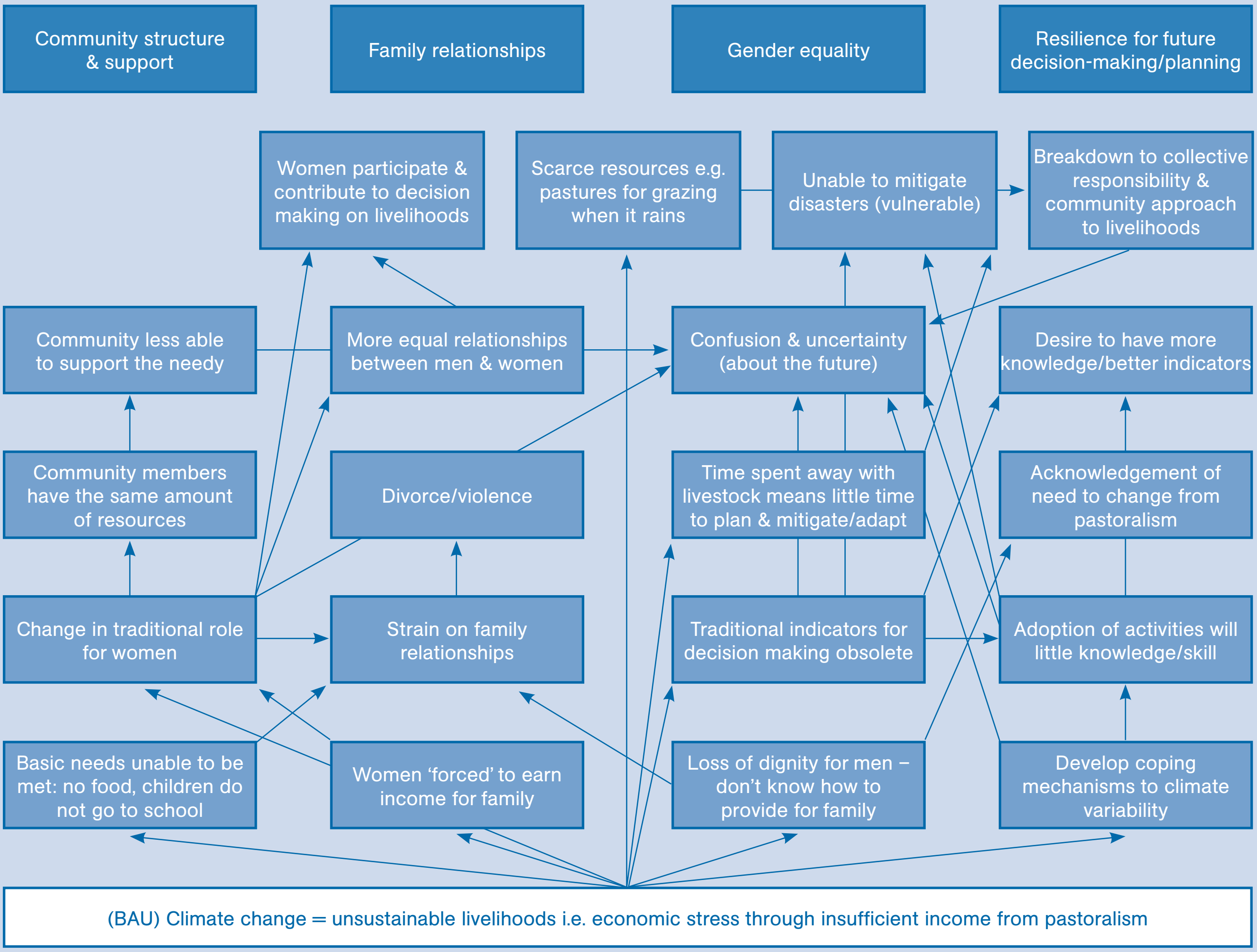
- **Family relationships:** key changes include increased stress within families, women gaining increased economic independence and empowerment as a result of working outside of the traditional roles. It is interesting to note that the two communities interpreted change differently: women in Saka reported an increase in divorce as a result of increased stress, which they interpreted as negative whilst women in Shant'abaq reported a decrease in divorce due to men lacking the finances to take another wife, interpreted as a positive consequence.

- **Gender equality:** Women reported having a greater 'voice' within decision-making. The willingness to pay exercise unearthed the extent to which women value this newfound role although it was acknowledged that men struggle with such a change to status quo.

- **Resilience for future decision-making/planning:** a key theme that emerges is the extent to which communities expressed a sense of confusion and uncertainty about the future. As their traditional indicators are no longer effective or appropriate, there was a strong sense that without support, they did not know how to progress in order to sustain their livelihoods and their families.

Overall, the communities no longer felt in control of their future and required more and better information to allow them to plan for the future.

Figure 9. *Social sustainability, social capital model and gender.*



3. Key findings and results

While numerous modelling combinations were used to assess total capital evolution (economic, social, environmental), here we present three possible scenarios.

The 'business-as-usual' scenario: main model and sensitivities
A full range of cost-benefit ratios encompassing modelling combinations is presented in Table 4 and Technical Appendix 8 presents a comparison between Saka and Shant'abaq.

Figures 10 and 11 present total capital evolution under business-as-usual, modelling optimistic (higher bound), pessimistic (lower bound) and mid-ground (mid-bound) assumptions.

Drought occurrence is constant and identical in the three forecasting estimations, due to the significant challenges of modelling variances in this. The differences between the scenarios are notably in (1) the assumptions relative to adaptive capacity of communities without external interventions and (2) the rainfall and temperature alternative scenarios.

The "BAU higher bound" scenario assumes a slight increase in rainfall over the next twenty years along with high adaptive capacity linked to livestock capital regeneration by the community. Equally, we assume a relatively high level of income substitution by the community itself – be it through migration and remittances, development of small agriculture or small business development.

Despite being an overly optimistic scenario for most ALP communities, total community capital still decreases over time, albeit slightly, from an average of 130 to 120 USD (2010) per community per year. This figure encompasses both actual productive output of communities and evolutions of social and natural capitals (in terms of ecosystem services) expressed in monetary terms. In per capita terms this signifies passing from above 1 USD a day to the absolute poverty line to 1 USD (2010) a day.

Scenarios "BAU mid-bound" and "BAU lower bound" are based upon, respectively, more modest and pessimistic assumptions. "BAU mid-bound" is based upon a stable rainfall patterns while "BAU lower bound" is based

Figure 10. *Total capital evolution under three, main business-as-usual scenarios (in 2010 rates for the USD).*

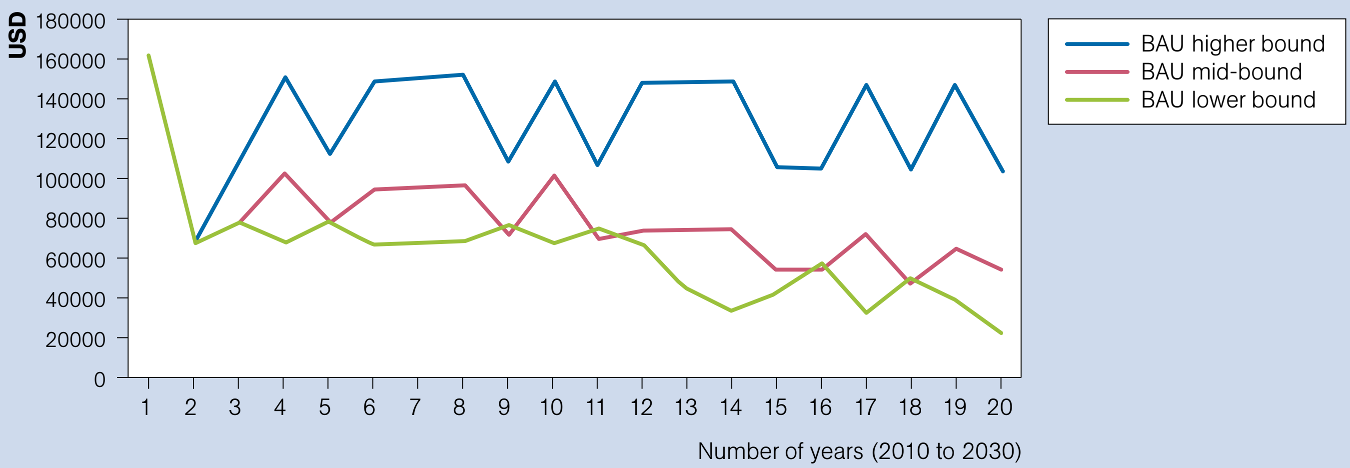
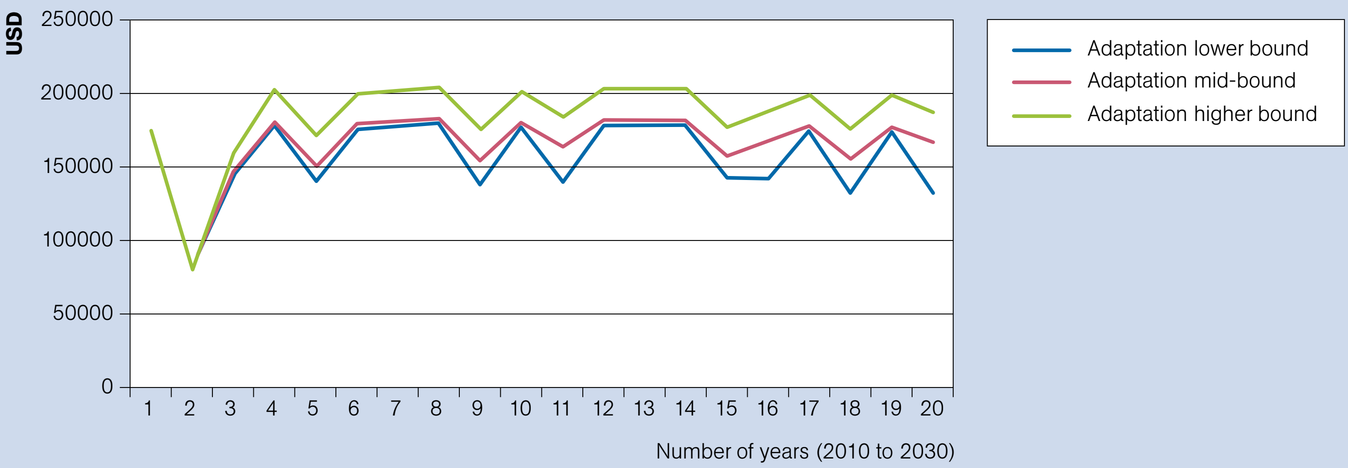


Figure 11. *Total capital evolution under main adaptation scenarios (in 2010 rates for the USD).*



upon a continuation of current decreasing rainfall trend. In both cases decrease of total capital is considerably sharper than in the "best case scenario". This is due to the assumptions used in these forecasting scenarios which include: (1) lower autonomous capital recovery rates notably as a consequence of; (2) more pessimistic rainfall scenarios; (3) more marked human development impacts.

Finally "BAU lower bound" models a sharp decrease in natural resource stocks as well as significant decrease of natural capital. This scenario combines a temperature increase along with rainfall decrease. Continuous (and steady) natural capital degradation is more marked than in the other scenarios.

The adaptation scenario: numerous variants

As per the business-as-usual analysis our adaptation scenario equally contains numerous sub-scenarios. These relate both to expected climate change patterns and to different diversification strategies. While we kept DRR measures identical in all sub-scenarios, we explored a multitude of possible combinations for income diversification strategies. Figure 10 illustrates the long-run impacts of three of these strategies across optimistic (higher bound), pessimistic (lower bound) and mid-ground (mid-bound) assumptions.

Keeping DRR measures and their impacts constant, these scenarios represent different combinations of investment in livestock-related activities and investment in agriculture. The "Adaptation lower bound" consists in a combination of: (1) replacement of livestock pastoralism by agriculture at a high magnitude (75per cent); (2) pessimistic agro-ecological assumptions, notably resource availability and future aridity levels (more marked for Shant'abaq than Saka); (3) high post-harvest losses. Finally, (4) the above elements imply a small financing capacity of community based insurance or bank: it is a worst-case scenario whereby income diversification strategy results in relative failure and "mal-adaptation" becomes a reality.

The "Adaptation higher bound" consists in a scenario of: (1) optimistic rainfall evolution; (2) 25per cent substitution of livestock pastoralism through small-scale agriculture, combined with (1) fodder cultivation in order to palliate and cope with external disasters in periods of drought as well as (2) other adaptation measures focusing on strengthening livestock pastoralism (see: Table 3, section 2). Moreover, a lower bound estimate is chosen for post-harvest losses, hence minimizing cradle-to-market income losses. This scenario represents a successful adaptation strategy in which income diversification sustains traditional pastoralist livelihoods. Finally it is worth noting that high value-added is obtained through agriculture as communities manage to cultivate relatively high value-added crops – such as mangoes – rather than low value-added ones whilst spurring overall benefits and community multiplier impacts.

Finally, the "Adaptation mid-bound" estimate represents an intermediate scenario in which, despite negative climatic evolutions (notably decrease in rainfall and length of growing period), a diversification strategy is apt to manage adverse impacts. Put simply, assumptions used are essentially identical to the "higher bound" scenario coupled, nonetheless, with negative climatic evolutions, i.e. higher bound rainfall decrease, higher bound temperature increase and thus lower bound LGP (Length of Growing Period).

It is worth explaining the causes of cross-year fluctuations in Figure 11. Fluctuations illustrate the impacts of external shocks, i.e. extreme weather events. The more permanent the impact of droughts and/or floods under any scenario (i.e. adaptation of business-as-usual), the more that we assume DRR measures *do not phase out* a relative decrease of total capital during extreme weather events. While they are apt in *smoothing* fluctuations under best-case, their main effect is to *allow faster and higher recovery rates* since part of existing capital (in all its forms, i.e. financial, economic and social) is saved – in terms of avoided losses. Under this assumption, it is logical to expect fluctuations regardless of the scenario modelled.

Confronting business as usual and adaptation: cost benefit results and ratios
Table 4 presents the range of cost-benefit ratios according to different assumptions made. Evidently, the models and assumptions permit a potentially infinite number of combinations. Here we present the range of some of these combinations reminding that a pre-condition to pass a cost-benefit test is a ratio above one i.e. when benefits exceed costs.

The World Bank has defined no regret adaptation as "adaptation options (or measures) that would be justified under all plausible future scenarios including the absence of manmade climate change".[62] Our modeling scenarios, based on data from the Kenya Meteorological Department, extrapolates current conditions without considering further stresses as a consequence of climate change. The higher positive ratios under this scenario mean under the World Bank definition, funding community based adaptation is Garissa, Kenya, is a "no regret" investment.

Table 4. *Cost benefit ratios and scenarios.*

	Sensitivities / Assumptions	Results range (CBR)
Discount rate	1 %	1.11 - 2.39
	4 %	1.02 - 2.11
	8 %	0.93 - 1.5
Rainfall forecast	Kenya Meteorological Department (BAU)	1.57 – 3.13
	IPCC – A2	1.32 – 2.87
	IPCC – B1	1.42 - 3.03
Temperature forecast	Kenya Meteorological Department (BAU)	1.92- 2.90
	IPCC – A2	1.65 - 2.36
	IPCC – B1	1.70- 2.52
Attainable yields forecast	Lower bound (example: millet)	1.15 - 1.37
	Higher bound (example: millet)	2.20 - 2.60
Post-harvest losses	20 %	1.92- 2.40
	50 %	1.12 – 1.50

Figure 12. *An overview of total capital evolution under adaptation vs. BAU (in 2010 rates for the USD).*

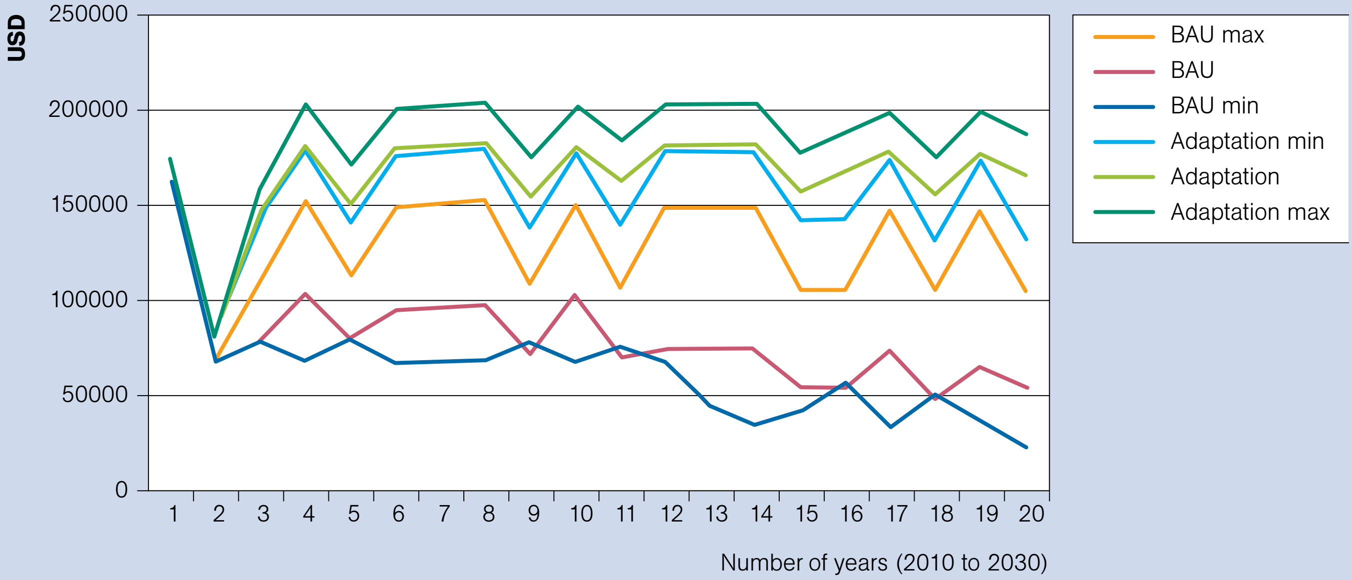
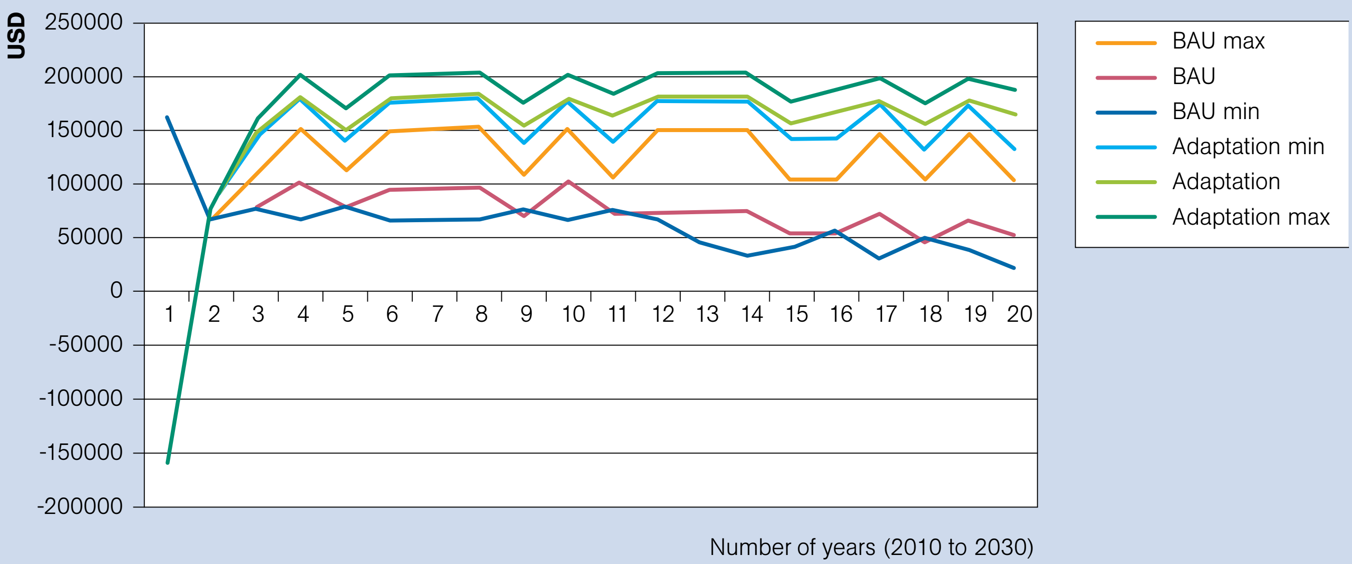


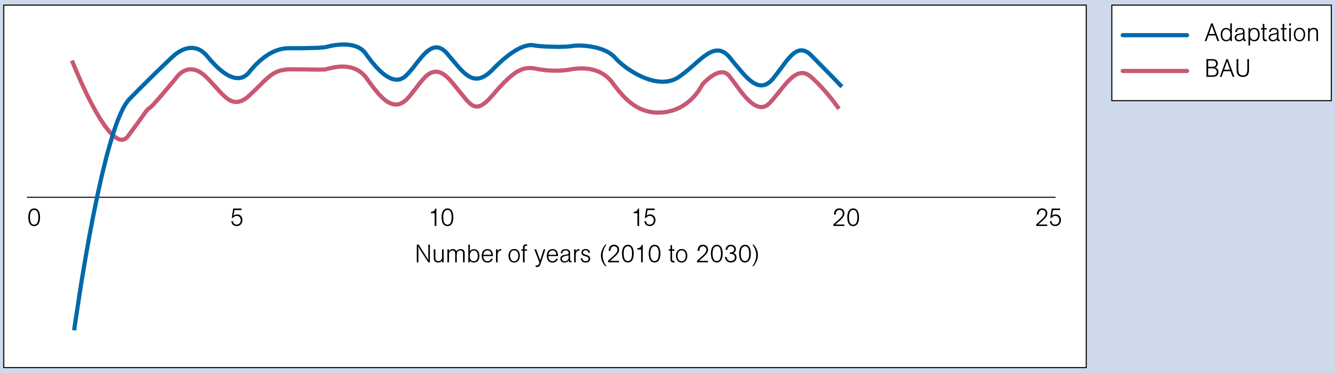
Figure 13. *An overview of total capital evolution factoring costs of adaptation (in 2010 rates for the USD).*



Figures 12 and 13 confront the three scenarios presented throughout the previous sections via an illustration of total capital evolution under the different scenarios. In-between the minimum (lower bound) and maximum (higher bound) BAU and adaptation scenarios, there are an infinite number of possible curves. Nonetheless, we present worse and best case scenarios along with one of many possible intermediate curves.

On economic efficiency grounds, worst case scenarios are perhaps the most significant. If a worst case scenario still points to net benefits then there is a strong economic rationale to invest in a project.

Figure 14. *A worst-case scenario: combining adaptation low bound with BAU high bound – factoring investment costs.*



vFigure 14 graphically compares: (1) a BAU scenario in which the impacts of climate change are projected to be relatively "mild" and communities are apt to present a high autonomous adaptive capacity, with (2) an adaptation scenario which ends in a relative "mal-adaptation" i.e. an adaptation that does not add much value to communities.

While total capital evolution under "adaptation" is still higher than BAU wealth level up to 2030, a further question consists in determining whether the Net Present Value (NPV) of the one outweighs the other.[63] Such is the object of the following section which tackles the issue of sensitivity, risk and uncertainty.

Assessing sensitivity, risk, and uncertainty

As illustrated by the debates surrounding the publication of the Stern Review a debatable element of cost benefit analysis consists in discount rate choice.[64] In cost benefit analysis, both benefits and costs are discounted to represent their present value. In the UK, the social discount rate (as opposed to financial/market discount rate, which is generally higher) is provided by the Treasury at a 3.5per cent level.[65] This rate represents time preferences: the higher the discount rate, the greater the assumed preference for the present is and the less a future stream of benefits ifs preferred. A high discount rate tends to favor projects which have high returns in the short run.

The choice of discount rates for social projects is a statement of how a society values returns. How important we consider the future to be depends on philosophical and cultural considerations such as intergenerational solidarity as described by Nobel prize-winning economist K. Arrow.[66]

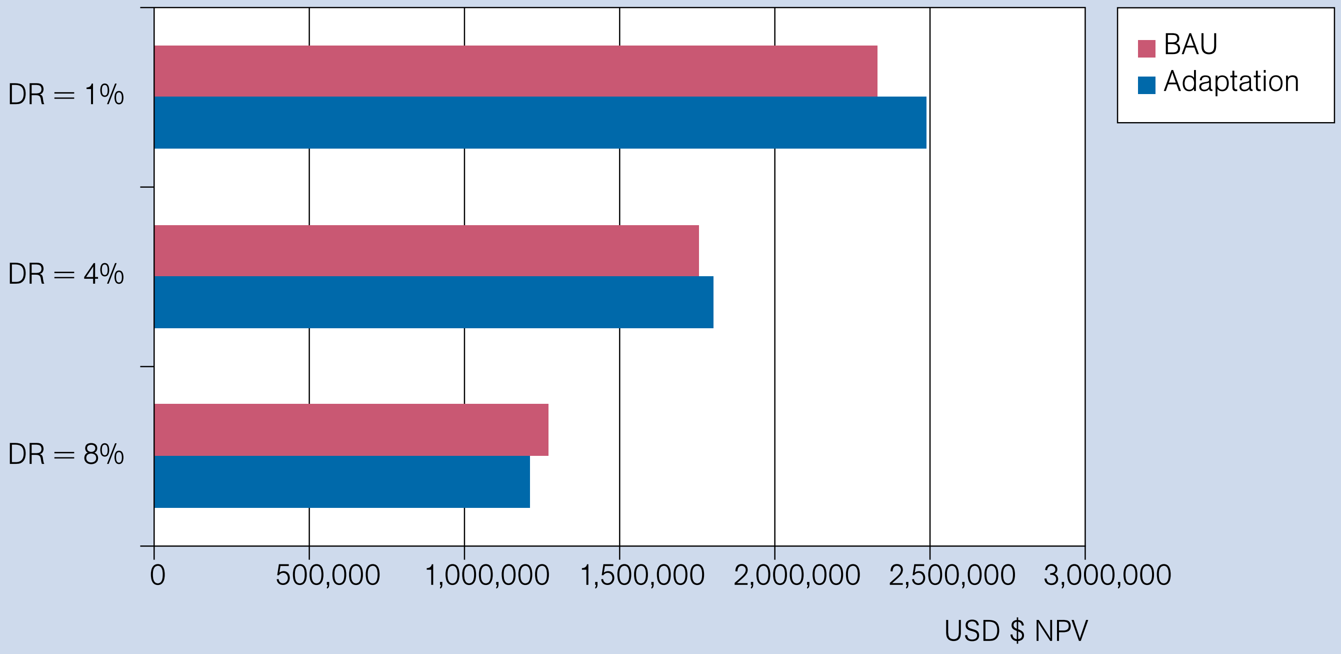
To avoid controversy, this analysis has modelled NPV under three discount rates 1per cent, 4per cent and 8per cent whilst encompassing sensitivity of results within the analysis. It is worth noting that an 8per cent discount is a very high figure, generally used for private, rather than social, project appraisals. Nonetheless, some economists argue that social discount rates of developing countries should be higher than the ones applied in developed ones, notably as a consequence of higher time preferences for the present.[67] Even if this assertion is equally debatable, positive cost-benefit ratios *even when using an 8per cent discount rate* provide a strong mandate for undertaking a project.

Figure 15 presents the worst-case scenario and its sensitivity to discount rate choice. The only result indicating a negative cost-benefit ratio is when comparing a best case BAU scenario with a worse case adaptation one and then *only* under a very high (8per cent) discount rate.

Table 5 provides an overview of different assumptions used in our models in order to factor sensitivity of results.

Uncertainty has largely been dealt with under our modelling assumptions. Indeed the use of multiple socio-economic and, not least, production scenarios

Figure 15. Worst-case scenario and NPV sensitivity to discount rate (in 2010 rates for the USD).



under numerous possible climatic evolutions ensure that impacts of uncertainty do not lessen the economic rationale for investing in adaptation in the region of Garissa. In fact, positive cost benefit ratios even when factoring uncertainty strengthen this investment case.

Finally, the **risk** of "mal-adaptation" has been dealt with under a worst case scenario – which still presents net benefits except when using an 8per cent discount rate. Admittedly, one risk this analysis doesn't factor is the possibility of annihilation of DRR measures through extreme weather events. In such case indeed, the risk of a complete destruction of DRR infrastructure could fundamentally alter our results. Nonetheless this possibility is admittedly very improbable.

Table 5. Sub-scenarios for sensitivity analysis and risk assessment.

Description: Sub scenarios:	Climate model	Economic/ financial models	Agricultural/ livestock models	Environmental model
Rainfall projections	1. KMD 2. A2 (IPCC) 3. B1 (IPCC)	Indirect impacts	Indirect impacts	Indirect impacts
Temperature projections	1. KMD 2. A2 (IPCC) 3. B1 (IPCC)	Indirect impacts	Indirect impacts	Indirect impacts
Attainable yields	Impacts of the three temperature/rainfall models on LGP (3 LGP scenarios)	Production capacity based on lower bound study	Soil productivity: based on two studies	Impacts on soil /water quality / GHG emissions (Two scenarios per component)
Crop market returns	N/A	Post harvest losses: two scenarios	N/A	N/A
Extreme weather events probability / impacts	1. Keeping the probability rate constant (1990-2010) 2. Increasing the probability rate	Impacts on human capital (health/education) and infrastructure.	Impacts on crop production: two scenarios	Impacts of extreme weather events also based upon vegetation cover: two scenarios (floods)

4. Implications, replicability and limitations

Positive cost-benefit ratios under multiple scenarios indicate an unequivocal economic justification for taking action, i.e. financing community based adaptation to climate change in Garissa, Kenya.

Implications for donors
Our analysis explored multiple adaptation strategy variants and assumptions, all of which were found to be economically efficient (i.e. benefits exceed costs). Only when combining a worst case scenario with a high discount rate of 8per cent discount rate is there a negative cost-benefit ratio.

While our results suggest a clear-cut *value-for-money* case for investing in community based adaptation in Garissa, Kenya, these results cannot prescribe components of projects. The economic rationale for investing in adaptation is unequivocal as per our results; we nonetheless equally consider cost-benefit ratios *magnitudes* less relevant in indicating *which* adaptation path should be taken. As already mentioned, adaptation strategies need to be re-oriented and re-designed according to future climate evolutions and eventual unexpected impacts. As such, CBA is poorly equipped to suggest 'silver bullet' strategies in a context of high future uncertainty.[68]

A first step when defining a long-run adaptation strategy is the broadening of productive capabilities and possibilities in order to spur long-term resilience. Such is notably the rationale for investing in drought-resistant agriculture in order to support traditional livestock pastoralism. Nonetheless, this partial income-substitution strategy might not be tailored to all community contexts: this is notably reflected by significantly higher cost-benefit ratios of investment in agriculture for Saka, compared to Shant'abaq – which is expected given Saka is situated along the River Tana (i.e. lower aridity). As such, the CVCA-empirically derived results could indentify specificities in order to design community-tailored, long-run adaptation strategies. In this respect, our results leave ample room for flexibility in terms of choosing an appropriate adaptation strategy.

It is also critical to distinguish two types of projects' components: short-run mitigation of effects from long-run productive transformation. While the former entails project components which suggest precise and clear-cut adaptation strategies (e.g. dealing with disasters; investing in health of both humans and livestock; enhancing natural resource managements) the issue of long-run productive transformation is more complex, debatable, context specific, and should thus be treated with caution.

A final concern of donors consists of the *opportunity* cost of financing a project. Put simply, allocating funds for adaptation potentially induces reduced funds for other sorts of financing, not least of strict development projects. We consider, however, in terms of climate change adaptation *in Garissa*, this distinction is nonexistent and hence that the opportunity cost could be zero. While this can, admittedly, be considered as a conceptual and modelling assumption, it is incumbent on us to set the arguments supporting this position:

- First, most identified coping strategies take the form of classical development interventions as per the *Millennium Development Goals*: such is the case of health, education, and nutritional levels increase.

- Secondly, income diversification does not solely constitute a protection towards future atmospheric evolutions in the strictest sense, but equally towards economic ones (e.g. market prices volatility) hence positively impacting, for instance, on food security.[69]

- Thirdly, even if heroically assuming climate change will not take place, hence forecasting a continuation of current trends, increasing access to resources and bettering their management *would still be a necessary component of any development policy*: indeed, current prevailing conditions are very unlikely to sustainably support an increasing population.[70]

- Fourthly, spurring community empowerment and awareness can constitute a prelude to broader *positive development externalities* of adaptation projects: these indirect effects were not taken into account in our analysis, although they could significantly increase the magnitude of benefits.[71]

- Finally, returns on investment are generally higher in poorer areas: such is the case of Garissa compared to Kenyan averages, although this was not statistically factored within our models.[72]

Implications for local development actors

As aforementioned, one of the specificities of climate change adaptation interventions consists in uncertainty relative to the degree, nature and characteristics of future climate change. This implies that there might not be silver bullet strategies to be extrapolated into the future: indeed a choice made today might result in "mal-adaptation" in the future in case climatic transformations are of different nature compared to expected ones. As such a flexible approach is required: the issue is less about spurring one specific form of transformation and more about broadening potential directions, i.e. broadening the capacity of communities to respond to change whichever this change is. For instance, maintenance of pastoralism along with a modest diversification through drought resistant crops cultivation can enhance the adaptive capacity of communities in the sense of providing them with alternative knowledge and know-how in case a shift to drought resistant agriculture becomes inevitable. Similarly, institution building and spurring political participation can help in tailoring existing social structures to respond to future natural disasters and productive necessities. This is where the notion of "dynamic planning" steps in: because a strategy cannot be immutable, priorities and decisions should be constantly re-thought and re-designed following observed changes.

The notion of "dynamic planning" is equally relevant to analyse the "hard" versus "soft" adaptation debate. While hard adaptation aims to spur productive capacities, it cannot necessarily respond to situations whereby infrastructures, priorities and choices need to be dynamically redefined. This is where knowledge, decision-making processes, capabilities and empowerment become critical and irreplaceable. And all these measures are defined as "soft" rather than "hard" adaptation. Ideally, as in our model, these two aspects should walk hand-in-hand provided that the communities can set priorities and access the information required to tackle such transformations and make decisions. Nonetheless, "hard" adaptation alone could be doomed to fail in a condition of high uncertainty regarding future conditions.

It is evident (at least in the case of Garissa) that climate change adaptation presents numerous "double dividends" for development policy. For example, diversification of incomes can be a form of insurance to livestock or crop prices volatility, hence spurring food security. Moreover, income diversification can and should entail a gender dimension, notably through an involvement of women within income generating activities as well as spurring their autonomy and involvement in decision-making processes. Similarly, numerous interventions aiming to spur adaptive capacity, e.g. education, information and health, are closely intertwined with development interventions. As such, strict development interventions and adaptation ones should take into account the numerous "double dividends" – provided that uncertainty is factored within the analysis and design of interventions.

Implications for regional and national policy-makers

A definition of clear regional strategies can steer community strategies in a coherent direction as well as spurring or alternatively hindering community strategies: the impacts of moving in radically different directions can have adverse self-cancelling impacts. As such, the local and regional intervention levels need to be articulated in a coherent manner. For instance, infrastructural investment on a regional scale can spur the benefits of community based adaptation. Similarly, if regional instances decide to steer an adaptation strategy in an agricultural direction, then this choice has evident impacts on livestock pastoralism viability as well as ecological sustainability. On the other hand, a clear strategy focusing on livestock as a vector of Kenyan ASALs development could potentially ensure the viability of pastoralism on the long run – despite adverse climatic impacts.

Secondly, top-down regional strategies should, insofar as possible, take into account uncertainty and dynamic planning. As aforementioned, the merits of soft adaptation consist in building flexibility within policy choices, thus broadening possibilities. Alternatively, such is not necessarily the case of "hard" top-down interventions – which can often have irreversible impacts and thus drive "mal-adaptation". Such is the case of steering the entire region towards one direction, e.g. pushing for agricultural development regardless of impacts on pastoralist economic and social structures. Consequently, rather than expecting communities to adjust ex post to regional choices, the alternative of embedding ex ante local adaptation into regional and national strategies in a bottom-up fashion could minimize the risks of "mal- adaptation" and respond to populations priorities and capabilities.

To conclude, what holds for the local and regional levels dichotomy is also relevant for development actors, donors and policy makers. While disproportionate attention has been given to grand adaptation schemes, empowering communities and populations to deal with climate change impacts is not only efficient and effective on its own right, but can also guide macro policy making and decisions when building regional and national adaptation strategies. Such bottom-up guidance could well be crucial in order (1) to avoid future "mal-adaptation" thus wasting resources in a financially constrained environment, (2) build strategies which are compatible with local needs and (3) prevent local conflicts over access to scarce resources in the already ecologically constrained environment which will be made worse by climate change.

Replicability and limitations

Replicability

If comparing the present analysis to other models used to economically appraise climate change adaptation interventions our approach has the following merits: Firstly, (1) it is not reductive in its scope, since it considers not only strict economic returns and capital but equally uses proxies to quantify environmental and broader social aspects of climate change impacts. Secondly (2), unlike the present study the vast majority of other models are not tailored to analyze climate change impacts and adaptation interventions on a local scale. A notable exception is the Community-based Sigmoid Exponential Disaster Risk (CSEDR) model. Nonetheless the latter focuses primarily on avoided damages induced by extreme weather events and associated DRR interventions, rather than long-run productive transformation. Finally (3) the use of systems dynamics allows to incorporate both the interactions between climate impacts and the socio-economic systems concerned, as-well-as their long-run dynamics – hence allowing to forecast the socio-economic impacts of climate change under numerous scenarios. This also implies that different adaptation measures and mixes can be modeled, as well as the sensitivities of results to numerous assumptions.

Despite the above merits, the fairly complex nature based on system dynamics modeling means that such a vast analysis is difficult to systematically replicate by NGOs or other development actors. Nonetheless, it is possible to simplify the model by taking into account a fewer number of key variables and as such, extend this type of analysis to further programmes, projects or policy interventions. If, through replication, it can be determined which type of variables, i.e. quantitative figures representing impacts, matter the most then it could be possible to standardize the model by taking into account fewer variables and fewer interactions between different variables. This simplification exercise is a pre-condition if wanting to economically appraise local adaptation projects through an effectiveness, rather than efficiency, angle.

Limitations

Despite robust findings, this work evidently contains numerous limitations.

- It does not factor **broader regional developments**, including conflict, possible future impacts of larger scale infrastructural development or broader regional strategies in terms of productive specialization. As such, it is a strict micro-economic exercise which assumes all other parameters being equal. It is evidently "heroic" to assume that the general environment in which these communities are embedded will not be transformed, positively or negatively, over a period of twenty years. Yet, this remark does not reduce the strength of our findings: on the one hand, positive regional development could *magnify* forecasted benefits to a great extent. On the other hand, negative regional developments still strengthen the case of community based interventions in order to build community resilience to external shocks – i.e. shocks produced in the environment in which communities operate. Therefore, it would be still possible to conceive additional avoided costs under pessimistic extra-climatic assessments on the future of Kenyan ASALs.

- This study focuses solely on **livestock pastoralism, livestock farming and drought-resistant agriculture** as means of an adaptation strategy. First, these means may not be fully compatible on a regional level: for example land enclosures, direct consequence of agricultural investment in some communities, can adversely impact on pastoralist activities of other communities. This is due to the nature of pastoralist activities and tacit social structures and mediation between communities. Similarly, unsustainable water use for agriculture could induce lower water availability for other communities, thus offsetting positive impacts. These considerations need to be taken into account in a holistic fashion. Secondly, other options should not be excluded, e.g. development of eco-tourism. In short, the bottom line is that any local option needs to be tailored to broader regional strategies. If, for instance, a substantial investment in and strategy for livestock promotion are carried through on a regional scale[71], then it could be preferable for communities to maintain their specialization– with associated support and adaptation measures tailored to livestock activities. Finally, in the debate between livestock pastoralism and drought resistant agriculture, it is critical to be context-specific. Indeed, and such is the case of Shant'abaq, information on the Merti Aquifer is poor in enlightening us as to whether drilling for irrigated agriculture is sustainable or not. Likewise, its water is too saline in some parts, whilst suggesting its water cannot be used across the entire region. Not even mentioning, in fine, its trans-boundary nature and associated potential tensions with Somalia if the Merti Aquifer was to be over-exploited in Kenya.

- Despite our effort to obtain relatively dynamic empirical evidence, our **information is still relatively static**. This links to the dichotomy between community appraisals and regional developments. For instance, we do not factor potential transformation of community life or possible mass rural-urban migration. Yet, this is far from an unlikely scenario, and could significantly reduce stress on natural resources and broader Malthusian equilibriums within the region of Garissa. Similarly, historical trends are to be considered, although these were beyond the scope of this analysis. For instance determining the conditions under which pastoralism has been the most sustainable and productive livelihood, and the factors which have eroded its historical resilience (e.g. population growth or external shocks), can provide meaningful information to enlighten current policy-making and eventually future strategies.

- **High degrees of uncertainty present challenges to all forecastive analyses**. In terms of developing an adaptation strategy, CBA alone is not the strongest tool, as this requires additional non-economic and community based factors to be considered. Therefore, when dealing with high levels of uncertainty, we suggest that social CBA can only be *part* of an appraisal process rather than the appraisal process *per se*. These remarks do not undermine the validity of our results but simply imply that deciding on an adaptation strategy should take into account other considerations such as: (a) water availability; (b) regional strategies; (c) interactions between communities; (d) the extent to which livestock pastoralism can walk hand-in-hand, or not, with agricultural investment – and if yes, to what extent; (e) a deeper understanding of potential environmental impacts of respective production decisions; (f) the distribution of costs and benefits across and between communities.

5. Conclusions and recommendations

This study highlights an unequivocal call for 'action' of investment in community based adaptation to climate change.

The socio-economic analysis indicates costs outweigh benefits even when accounting for risk and uncertainty – as such, positive findings under a multitude of scenarios, including sensitivity analysis *proves* the robustness of the results. In a context of high uncertainty, economic diversification provides for the necessary flexibility in terms of long-run planning in order to possibly re-define objectives according to unexpected positive/negative future developments.

This study raises further questions about the interrelatedness of different forms of capital; the valuation of costs and benefits associated with these and how to make evidence-based decisions on community based adaptation. We therefore recommend the following, that:

1. **Specific adaptation measures are tailored to the contexts in which the communities exist and function:** CVCA work is critical in this respect, especially when referring to import substitution measures/incentives.

2. **Diversification through agriculture should be implemented in a sustainable fashion**, as it will more likely than not, have higher adverse impacts on ecosystem services than livestock pastoralism, as per our findings.

3. **The approach of tailoring community based interventions to the needs of communities is adopted for larger regional developments, in order to avoid overall negative externalities on other communities.** CBAs of community based interventions need to take into account broader regional conditions and developments.

4. **Hard adaptation measures that can only be implemented on a regional scale are critically important in spurring or constraining the benefits of community based adaptation.** This is relevant to both drought-resistant agriculture and the future of livestock pastoralism.

5. **Ultimately, local strategies need to be situated within regional governance strategies.** Indeed, consistent governance structures are critical in order to link community plans to broader local government strategies and DRR on a regional scale. In other terms, constructing consistent strategies and linkages between community scale and the regional level requires no less than institutional development, which should consequently be addressed by any robust adaptation strategy. Governance improvement would also spur positive development externalities given that the role of institutional development in economic development has been widely acknowledge both theoretically and empirically[72].

6. Further research is required:
   - On the adaptation strategies suitable for the region of Garissa, particularly concerning water resources but also land management. This information can typically allow building robust strategies, both on regional and local scales.

   - **To 'test' the replicability of this methodological approach to decision-making at a local level and on other communities.** This study expects that each country and culture will be different, albeit with a number of common socio-economic themes.

7 **Social cost benefit analysis has limitations in its ability to select the appropriate adaptation strategy alone.** Its limitations in dealing with high levels of uncertainty should be recognised and the approach viewed as one tool within an array of appraisal options when determining a community based adaptation strategy.

Whilst this study demonstrates that investment in community based adaptation is economically efficient, it also acknowledges that it may invite more questions than it answers. Further research is required to determine the replicability of this approach to other geographies, as cultural, social, economic and environmental contexts will vary with climate change and climate variability.

Taking account of economic, social and environmental capital and placing these in a currency that allows decisions to be made is crucial for ensuring that value for money is achieved in all investment decisions. It is our aim that ALP and other programmes within the sector benefit from this approach in their goal of supporting resilient, sustainable livelihoods through community based adaptation.

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