Economics of Climate Adaptation

August 2021

Executive Summary

Ethiopia Drought Risk

UNITED NATIONS UNIVERSITY
UNU-EHS

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List of Acronyms

AED	Annual Expected Damage
BMZ	German Ministry for Economic Cooperation and Development
CCA	Climate Change Adaptation
CRGE	Climate Resilient Green Economy
ECA	Economics of Climate Adaptation
EFCCC	Ethiopia's Environment, Forest and Climate Change Commission
EM-DAT	Emergency Events Database
GTPII	Growth and Transformation Plan II
ISF	InsuResilience Solutions Fund
KfW	German Development Bank
MoARD	Ministry of Agriculture of the Federal Democratic Republic of Ethiopia
NAP	National Adaptation Plan
NAPA	National Adaptation Program of Action
NAP-ETH	Ethiopia's National Adaptation Plan
NbS	Nature-based Solutions
UNU-EHS	The United Nations University - Institute for Environment and Human Security

MAIN FINDINGS

In this report, drought adaptation measures were analyzed for the Afar and Somilai regions in Ethiopia in terms of cost-efficiency and risk mitigation effectiveness. A total of 26 measures (13 options of measures in each region) were successfully assessed using the modelling platform CLIMADA. The main findings are summarized below:

1) The present annual expected damage is USD 35m in Afar and USD 123m in Somali, increasing to USD 217m and USD 788m by 2050 (moderate climate scenario);
2) All selected measures are cost efficient for the selected assets;
3) Yet, all measures combined are not sufficient to account for the total climate risk presented by drought. A significant higher investment is needed to address the issue at this scale;
4) By 2050 all measures for drought will be cost-efficient, with co-benefits for population at risk, under extreme climate conditions;
5) Climate index insurance for crops and livestock are cost-efficient and can help cover parts of the remaining risks, so called residual risks, after the most efficient physical adaptation measures have been implemented;
6) The top three cost-efficient measures for Afar are:
    a. Improved forage storage
    b. Management of protected areas
    c. Establishment of communal seeds bank
7) The top three cost-efficient measures for Somali are:
    a. Establishment of communal seeds bank
    b. Wetland Restauration
    c. Establishment of fodder tree and grass nurseries
8) With the top six cost-efficient measures, the Afar and Somali regions will be able to avoid an estimated USD 500 million in damages and protect around 90 000 people over the next 31 years with an investment of under USD 10 million.

Economics of Climate Adaptation

Powered by CLIMADA

1 CONTEXT

1.1 Introduction

Storms, floods, droughts, and other extreme weather events can threaten urban and rural areas, from small regions to entire nations. Along with growing populations and economies, losses from natural hazards are rising in the world's most exposed areas as our climate continues to change. The Economics of Climate Adaptation (ECA) is a decision-making support framework that integrates climate vulnerability and risk assessments with economic and sustainability impact studies to determine the portfolio of optimal adaptation measures for various climate risks.

The United Nations University - Institute for Environment and Human Security (UNU-EHS) in cooperation with and funded by the InsuResilience Solutions Fund (ISF), is implementing the Economics of Climate Adaptation (ECA) framework in the Afar and Somali regions in Ethiopia, to identify the most cost-efficient measures to address the negative impacts of droughts. The ISF is funded by the German Development Bank (KfW) on behalf of the German Ministry for Economic Cooperation and Development (BMZ). Currently, the Economics of Climate Adaptation (ECA) methodology is being implemented in three different countries (Vietnam, Honduras, and Ethiopia).

This report presents an executive summary of the different stages of the process of implementation of the ECA study and the final recommendations for adaptation measures to drought events in the Somali and Afar regions in Ethiopia. Over the period of the project, representatives of the Ministry of Agriculture of the Federal Democratic Republic of Ethiopia (MoARD), local governments, and further stakeholders engaged in providing input and feedback on the assumptions, decisions, data, and adaptation options assessed. A total of 26 (13 in Afar and 13 in Somali) drought adaptation measures were identified and validated by the MoARD and other stakeholders to be run by the modelling platform CLIMADA, including technological and engineering solutions, ecosystem-based (nature-based) approaches, maintenance/ operational measures, and risk transfer/ insurance solutions.

1.2 Background

According to Germanwatch, a Think Tank focussing on global development, climate change and environmental protection, Ethiopia is worldwide the 29th country with the most fatalities related to climate change in the two decades between 1999 and 2018, and 3rd in Africa for the same period.[1] At the same time, Ethiopia’s high population growth suggests that future events will affect more people and possibly leave behind a higher number of fatalities.

In the last 58 years, Ethiopia has faced 110 recorded natural disasters.[2] Figure 1 shows the distribution of such events by type of disaster, floods being the most common events with nearly

[1] Germanwatch (2019). *GLOBAL CLIMATE RISK INDEX 2020.* Bonn: Bread for the World.

[2] EM-DAT (2020). *EM-DAT Data Base*. Retrieved from EM-DAT: https://www.emdat.be/

half of the total occurrences, followed by epidemics and droughts. Climate-related disasters are mainly floods and droughts and represent over 60% of the events.

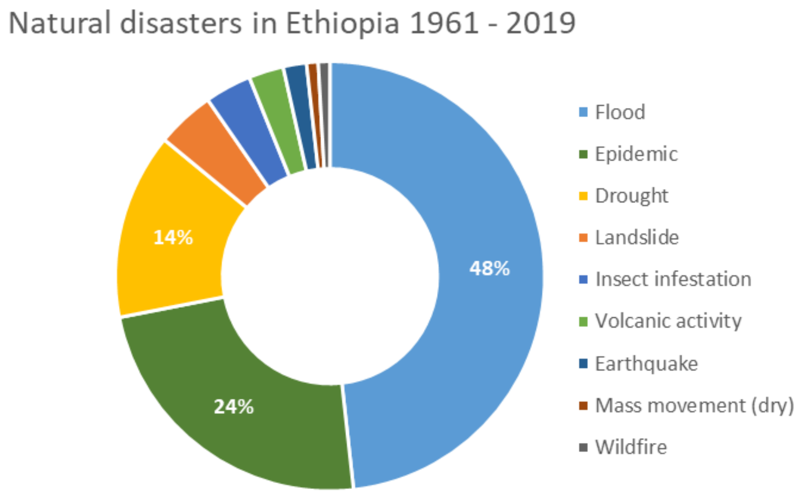

Figure 1 Type of Natural disasters in Ethiopia 1961 – 2019 (Authors' own compilation based on data from EM-DAT (2020))

Figure 2 shows how droughts are overwhelmingly affecting communities, both in fatalities and non-deadly affected population. The most destructive events took place in 2003 and 2015, the latter taking place during a strong El Niño Southern Oscillation (ENSO) year.[3]

According to the Ethiopia UNDP Climate Change Country Profile[4,5] the mean annual temperature in Ethiopia can be expected to increase by 1.1 to 3.1°C, and by 1.5 to 5.1°C by 2060 and 2090 respectively. Projections on precipitation primarily indicate an increase in annual rainfall, mostly during the short rainfall season dominant in southern Ethiopia. However, projections consistently show an increase in rainfall volumes concentrated in fewer but more extreme events. Considering the projected increase in temperature and the shift in precipitation patterns, total rainfall during fewer more intense events combined with increasing heat stress, droughts are expected to remain the most damaging events in Ethiopia and adaptation to them should be prioritized.

[3] Gleixner, S., Keenlyside, N., Viste, E. et al. (2017) The El Nino Effect on Ethiopian Summer Rainfall. Clim Dyn 49: 1865. https://doi.org/10.1007/s00382-016-3421-z

[4] McSweeny, C., New, M., Lizcano, G. (2010). UNDP Climate Change Country Profiles – Ethiopia. UNDP. Available http://country-profiles.geog.ox.ac.uk/

[5] McSweeny, C., New, M., Lizcano, G. (2010). The UNDP Climate Change Country Profiles Improving the Accessibility of Observed and Projected Climate Information for Studies of Climate Change in Developing Countries. Bulletin of the American Meteorological Society, 91, 157-166.

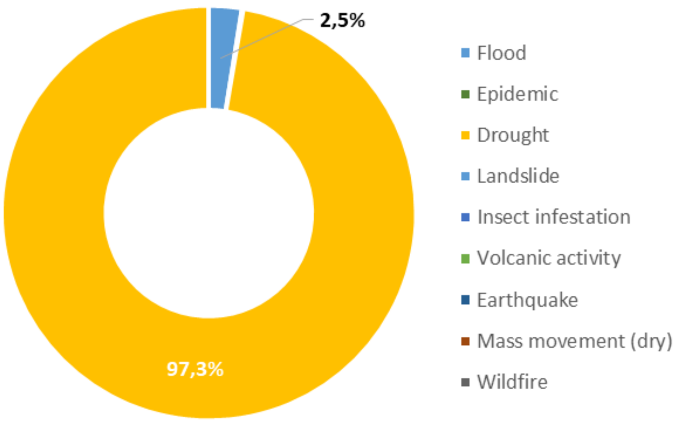

Figure 2 Affected people in Ethiopia (1961-2019) (after EM-DAT *(2020))*

1.2.1 Policies and strategies to address Climate Change in Ethiopia

Ethiopia has a strong history of addressing climate adaptation. In 2007 the National Adaptation Program of Action (NAPA) was first published. It was followed by the Growth and Transformation Plan II (GTP II) in 2011. The latter incorporated the framework of sustainable development within the overall vision of "reaching middle-income status before 2025 and a carbon-neutral economy by 2030".[6] The strategy set within this document was to follow a green growth path named the Climate Resilient Green Economy (CRGE). It aimed at boosting the agriculture, industrial and export sector without significantly increasing the GHG emissions level caused by the economy of the time.[7]

In terms of agriculture, the Ethiopian Government published in 2015 the Livestock Master Plan 2015 - 2020 as a contribution to the GTP II covering dairy cow, red meat, poultry, livestock feed, health and genetics, and promoting institution and policy environment for implementation.[8] As part of the CRGE, the climate resilience strategy for agriculture and forestry aims at identifying the impact of both current and future climate signal for Ethiopia. Ultimately, it highlights options for building climate resilience and to understand how these options can be delivered by 2025.[9]

In 2019, the Climate Resilient Green Economy - National Adaptation Plan published by the Government of Ethiopia and coordinated by Ethiopia's Environment, Forest and Climate Change Commission (EFCCC) followed the previous documents, with a compilation of the goals and strategies and as a guideline on how these and other policies align into one vision. Roles and responsibilities, e.g. regarding the implementation of the individual elements, are defined within the document from the national government down to the woreda level.

Specifically, in relation to droughts, the Productive Safety Net Program (PSNP) is being implemented by the Government of Ethiopia and supported by a range of international development partners. It provides a tool for governmental and non-governmental organizations to expand mitigation actions for drought impacts. Although the PSNP is designed to alleviate food

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[6] Federal Democratic Republic of Ethiopia. (2011). Ethiopia's Climate-ResilientGreen Economy - Green economy strategy. Addis Ababa.

[7] Federal Democratic Republic of Ethiopia. (2015). Ethiopia's Climate ResilientGreen Economy - Climate resilience strategy agriculture and forestry. Addis Ababa.

[8] Shapiro, B., Gebru, G., Desta, S., Negassa, A., Negussie, K., Aboset, G., & Mechal, H. (2015). Ethiopia livestock master plan - Roadmaps for growth and transformation. Addis Ababa.

[9] Federal Democratic Republic of Ethiopia. (2019). Ethiopia's Climate Resilient Green Economy - National Adaptation. Addis Ababa.

insecurity and not as means for emergency relief, during the drought of 2015 the increased ability of these institutions to react after the first signs of the event, significantly reduced the vulnerability of the communities in need.[10]

In this context, the ECA methodology offers benefits for policy- and decision-makers in terms of determining their portfolio of adaptation measures, prioritizing according to cost-efficient criteria and from an investment perspective. This ECA study assesses the distribution of damages associated to drought risk in the Afar and Somali regions. It also provides an assessment of different options for adaptation, including infrastructure, ecosystem and community-based measures. Therefore it allows stakeholders to make better-informed decisions on their climate adaptation strategies.

1.3 The ECA Framework

For the analysis presented a specific open-source modelling platform (CLIMADA) was used following the so-called Economics of Climate Adpaptation methodology (ECA). The main objectives of the ECA methodology are to support decision-makers in developing their adaptation strategy and climate change adaptation (CCA) investment portfolios, including risk transfer. The ECA methodology offers a systematic and transparent approach that fosters trust and initiates in-depth inter-sectoral stakeholder discussions. The methodology can be flexibly applied from the national down to the local level to different stakeholder groups and different hazards. It further gives guidance on what aspects to focus on during a feasibility study. It provides key information for program-based approaches, insurance approaches and has the potential to support National Adaptation Plans (NAPs) development.

ECA offers a unique approach towards the flexible identification of cost-efficient CCA measures for a variety of projects and sectors. It addresses, in particular, the following questions:

1) What is the potential climate-related damage over the coming decades?
2) How much of that damage can be averted, using what type of CCA measures?
3) What investments will be required to fund those CCA measures and will the benefits of these investments outweigh their costs?
4) How do we quantify residual risks (i.e. the risk remaining once all considered physical CCA measures are implemented)?

A plethora of approaches has already been designed to respond to the complexity of climate change-related projects. With regard to the implementation of climate change adaptation strategies, they range from climate vulnerability assessments, risk assessments, economic and/or sustainability impact assessments to decision-making support tools. Among these approaches, none integrates the full range of processes from risk assessment to a feasibility study of CCA measures. Integration is the strength of ECA; it is linked to the open-source modelling platform CLIMADA. The latter, by using available data, calculates the potential impact of current and future hazards on several selected assets, including the cost/benefits of selected measures.

[10] Sohnesen, T. P. (2019). Two Sides to Same Drought: Measurement and Impact of Ethiopia's El Nino Drought. Poverty, Inequality and their Associations with Disasters and Climate Change. Venice.

2 IMPACT ASSESSMENT

2.1 Methodology Overview

The Economics of Climate Adaptation (ECA) framework is set out to develop practical recommendations that enable national and local decision-makers to build a comprehensive assessment of the climate risk that their economies are facing while minimizing the cost of adaptation through cost-efficient strategies. A particular emphasis is made on a robust and integrated approach based on sound scientific facts.

The ECA, as applied here, contains three elements supported by the modelling platform CLIMADA:

1) Climate risk identification: Conduct an identification of climate risk in a defined region (e.g. rural area), identify areas and people at risk, spanning all significant climate hazards and the full range of possible impacts for different sectors
2) Climate risk quantification: Calculate the expected damage across multiple climates and economic scenarios
3) Identification and prioritization of CCA measures (using Cost-Benefit Analysis of CCA measures): Determine strategies including a portfolio of specific CCA measures with detailed cost/benefit assessment.

Other elements of the ECA methodology include stakeholder engagement to ensure ownership and sustainability of the measures for implementation.

Stakeholder Engagement: In the case of Ethiopia, a series of workshops have been conducted to include the views of stakeholders from different sectors. These inputs range from providing data to validation of assumptions, surveys or facilitating exchanges between parties.

Index-based Drought Risk Modelling: For the purpose of this study, an index based drought module has been developed for CLIMADA. This new module allows the user to choose between six different indices (depending on the region) and between a range of precipitation products. In the case of Ethiopia, high quality satellite-derived precipitation dataseries were selected for the simulations. The index used in these simulations has been documented to be very reliable for agricultural, hydrological and meteorological drought predictions. This drought model, as well as all data, has been transferred to the beneficiaries of the study, in order to allow updates and additional analysis in the future by the community itself.

Asset Valuation: In collaboration with all stakeholders, 12 different types of assets were selected and valuated using field surveys, expert interviews, and desk research. Asset values used in this study were validated during an iterative process with the different stakeholders. Table 1 and Table 2 provide an overview of the aggregated value per asset category.

Table 1: Asset Value Summary – Afar

Afar Asset Category	Total Value	Unit	Total Number
People	1 904 414	People	1 904 414
Camel	279 455 647	USD	802 711
Cattle	840 260 403	USD	2 946 525
Shoat	109 469 406	USD	1 384 287
Permanent water bodies	2 675 585 000	USD	55 000 ha
River	379 348 428	USD	3 501 km
Wood land	65 365 000	USD	85 000 ha
Shrub land	1 714 870 000	USD	2 230 000 ha
Herbaceous vegetation	3 561 310 000	USD	2 230 000 ha
Herbaceous wetlands	486 470 000	USD	10 000 ha
Un- & sparsely vegetated areas	1 817 272 500	USD	5 392 500 ha
Crop lands	963 120 000	USD	120 000 ha
Total Asset Value	12 892 526 385	USD	

Table 2: Asset Value Summary – Somali

Somali Asset Category	Total Value	Unit	Total Number
People	6 063 108	People	6 063 108
Camel	1 726 650 692	USD	4 959 645
Cattle	1 417 183 005	USD	4 969 608
Shoat	901 596 598	USD	11 401 070
Permanent water bodies	-	USD	-
River	729 698 928	USD	6 734 km
Wood land	1 059 297 500	USD	1 377 500 ha
Shrub land	20 747 620 000	USD	26 980 000 ha
Herbaceous vegetation	3 812 837 500	USD	23 875 00 ha
Herbaceous wetlands	121 617 500	USD	2 500 ha
Un- & sparsely vegetated areas	581 325 000	USD	1 725 000 ha
Crop lands	1 906 175 000	USD	237 500 ha
Total Asset Value	33 004 001 723	USD	

2.2 Expected Damage Today and in the Future

The annual expected damage (AED) is an estimation of the average foreseeable effects on assets and people per year, in this case, related to drought. AED can be measured in percentage or absolute values and incorporates climate change and socio-economic scenarios. One economic scenario and two climate scenarios were selected for this study. Figure 3 and Figure 4 show annual expected damage in Afar and Somali regions for assets in USD (Graphs a) and b) below) and for people (vulnerable population and other) (Graphs c) and d) below). The first bar (today) in yellow represents annual expected damage today. The second bar in light orange (economic development) represents the increase of the expected annual damage over the next 31 years due to economic development (for persons, it represents the population growth).[11] The light red bar represents the additional annual expected damage due to climate change in Ethiopia. Last, the darker red bar represents the total aggregated expected annual damage in 2050, when economic growth (or population growth) and climate change are considered.

Results are presented for all scenarios separately and aggregated with today's expected damage. Defining 2020 as today in alignment with discussions with stakeholders.

Afar: For the Afar region, the total expected damage for assets of USD 35m (2020) is expected to rise by 381% due to economic growth and of 138% due to climate change (144% in the extreme climate scenario). A total of USD 217m (USD 220m for extreme climate change scenario) are simulated for the time horizon 2050. The increase in annual expected damage in 2050 represents a raise of more than 520% in Afar, due to both, economic growth (assets will be more valuable) and climate change (hazard will be more frequent and more intense). This large increase is mostly reflected by a strong economic growth prediction. In addition, drought events are expected to worsen in the coming decades. Regarding the population, more than 53 000 people are expected to be affected by drought annually in 2020. Despite a relatively low population growth in the area, an increase of 266% is expected in the future. More intensive climate, in return is expected to affect more persons with an increase of 61% for a moderate climate and 98% for extreme climate. Taking economic growth and climate change into account, a total of 226 000 (245 000 for extreme climate) are expected to be affected annually in 2050, i.e. an increase of 327% and 364% compared to 2020.

Somali: For the Somali region, the total expected damage for assets of USD 123m (2020) is expected to rise by 326% due to economic growth and of 213% due to climate change (341% in the extreme climate scenario). A total of USD 788m (USD 946m for extreme climate change scenario) are simulated for the time horizon 2050. The increase in annual expected damage in 2050 represents a raise of more than 540% in Somali, due to both, economic growth (assets will be more valuable) and climate change (hazard will be more frequent and more intense). Regarding people, more than 159 000 people are expected to be affected by drought annually in 2020. Despite a relatively low population growth in the area, based on the analysis the number of people expected to be affected will increase by 248% in the future. More intensive climate, in return is expected to affect more persons with an increase of 58% for a moderate climate and 93% for extreme climate. Taking economic growth and climate change into account, a total of 647 000 (702 000 for extreme climate) are expected to be affected annually in 2050, i.e. an increase of 306% and 341% compared to 2020.

[11] For Afar annual population growth rates of 3.02% in 2018 to 1.76% in 2030 and 1.35% in 2050, and a declining discount rate of 6.2% in 2018, 4.00% in 2030 and 2.22% in 2050 is being assumed. For Somali annual population growth rates of 2.63% in 2008 to 1.96% in 2030 and 1.40% in 2050, and a declining discount rate of 4.8% in 2018, 4.03% in 2030 and 2.23% in 2050 is being assumed. Since little local information was available on economic growth a national estimate of 5.82% annually had to be assumed. These growth rates lead to a constant increase in the value of existing assets as well as the continuous accumulation of further assets. In the case of natural resources it is too assumed that the relative value increases with the GDP.
For further details on the socio-economic scenario please see the previous report: Waldschmidt, F, Rojas, A, Behre, E, Daou, D, Sebesvari, Z, Kreft, S, Souvignet, M. (2020). *Base Data Report – Ethiopia – Drought Risk.* Report 02. Bonn. UNU-EHS.

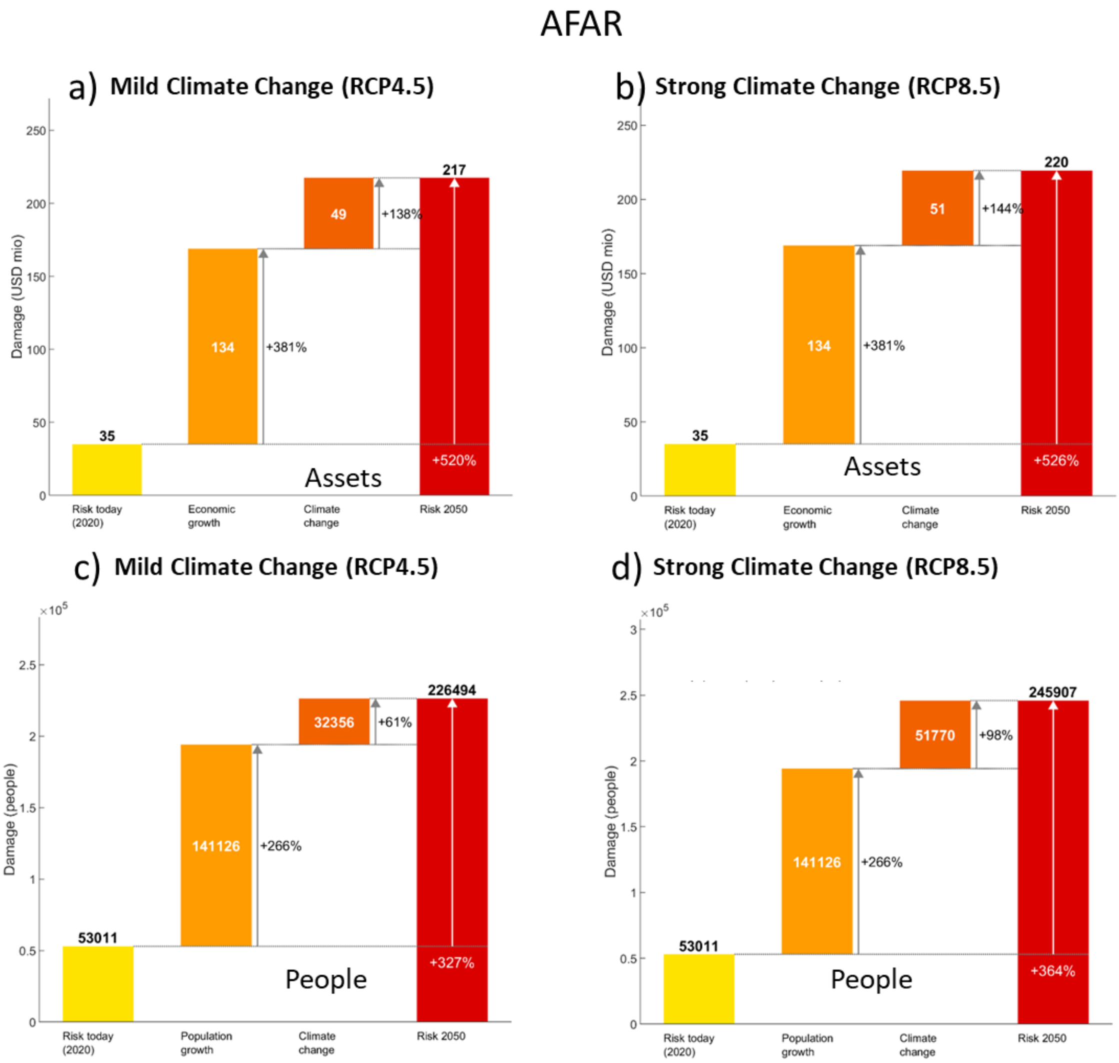

Figure 3: Annual expected damage (AED) in Afar for Assets (Graphs a) and b) in USD) and people affected (Graphs c) and d) in people).

SOMALI

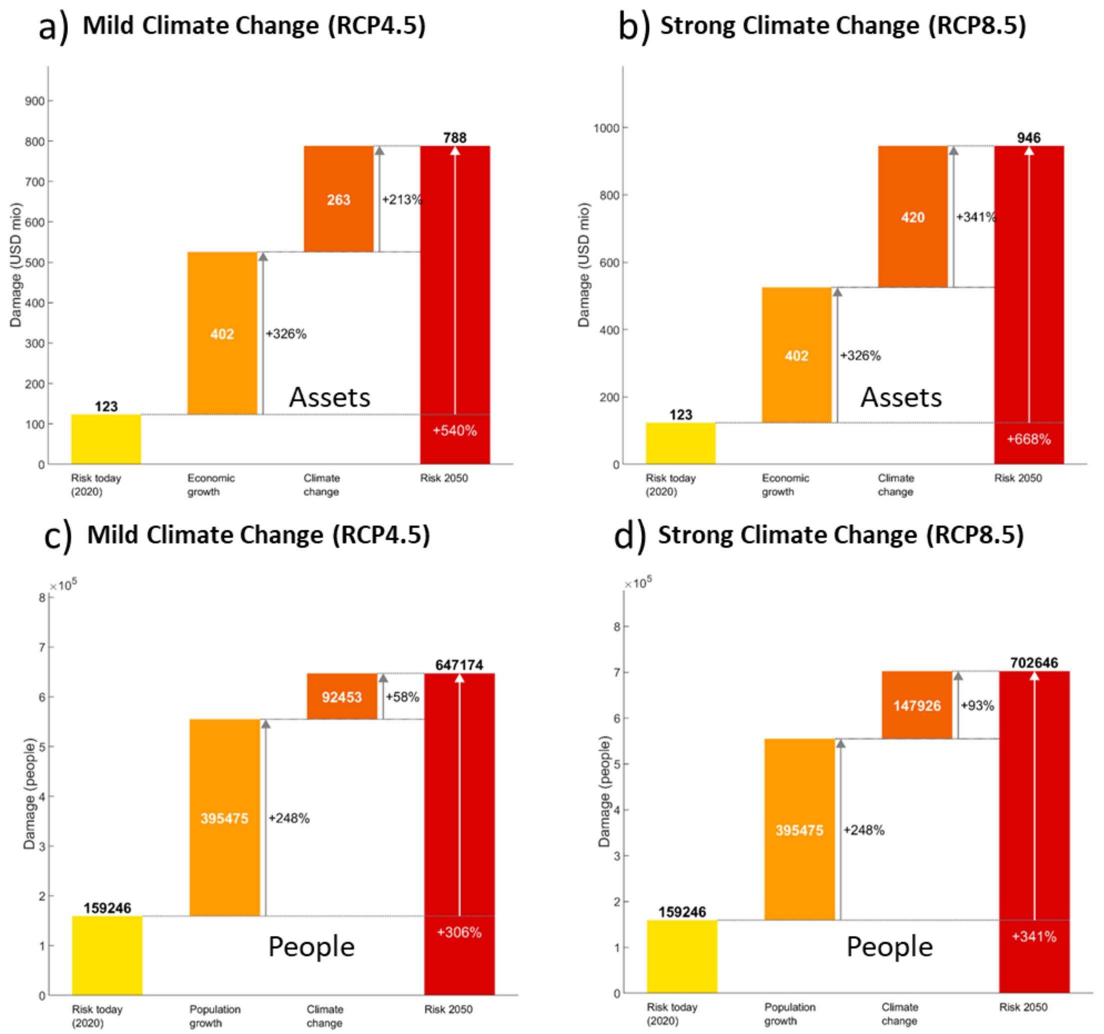

Figure 4: Annual expected damage (AED) in Somali for Assets (a,b in USD) and people affected (c,d in people).

3 ADAPTATION OPTIONS

3.1 Measures Costing

The adaptation measures were selected based on a comprehensive literature review and a consultation process with key experts and government representatives. In total 37 adaptation measures were initially identified (referred to as a “long list”) and reduced to 13 (referred to as a “short list”), in a transparent and participative selection process, including several stakeholder assignments and conducting a Multi-Criteria Analysis. Thirteen measures per region were introduced to CLIMADA, and later three per region were highlighted as optimal by the modelling platform:

- The top three cost-efficient measures for Afar region:
    a. Improved forage storage
    b. Management of protected areas
    c. Establishment of communal seeds bank
- The top three cost-efficient measures for Somali are:
    a. Establishment of communal seeds bank
    b. Wetland Restauration
    c. Establishment of fodder tree and grass nurseries

These six measures were further assessed during the pre-feasibility phase of the ECA study.

Table 3: Overview List of Drought Adaptation Measures for Ethiopia

AFAR REGION		
Measure	Type[12]	Total Cost in USD (for 31 years, incl. construction & maintenance)
Wetland restoration and rehabilitation	NbS	834 750
Intercropping of trees with crops (Agroforestry)	NbS	546 530
Replanting of indigenous and improved fodder trees and grass species	NbS	628 400
Management of protected environmental areas	NbS	907 986
Establishment of fodder tree and grass nursery sites	Hybrid	3 007 000
Subsurface Dams in Riverbeds	Hybrid	502 871
Riverbank restoration	Grey	1 176 622
Improvement of water storage systems	Grey	188 475
Improved forage storage & treatment	Grey	874 880
Establishment of communal seed banks	Grey	1 938 000
Establishment & Rehabilitation of small- & medium sized irrigation systems	Grey	12 724 998
Livestock Index Insurance	Risk Transfer	5 000 per 500 of each livestock/a
Crop Index Insurance	Risk Transfer	42 000 per 5x5km raster /a
TOTAL		23 330 512

[12] ‘Grey’ measures refer to technological and engineering solutions. ‘NbS’ measures refer to ecosystem-based (or nature-based) solutions and make use of multiple services provided by ecosystems. ‘Hybrid’ solutions indicate a combination of NbS and Grey types of measures. ‘Insurance’ solutions cover residual risks, which remain after alladaptation measures have been implemented

SOMALI REGION		
Measure	Type	Total Cost in USD (for 31 years, incl. construction & maintenance)
Wetland restoration and rehabilitation	NbS	834 750
Intercropping of trees with crops (Agroforestry)	NbS	546 530
Replanting of indigenous and improved fodder trees and grass species	NbS	628 400
Management of protected environmental areas	NbS	907 986
Establishment of fodder tree and grass nursery sites	Hybrid	3 007 000
Subsurface Dams in Riverbeds	Hybrid	502 871
Riverbank restoration	Grey	1 176 622
Improvement of water storage systems	Grey	188 475
Improved forage storage & treatment	Grey	874 880
Establishment of communal seed banks	Grey	1 938 000
Establishment & Rehabilitation of small- & medium sized irrigation systems	Grey	12 724 998
Livestock Index Insurance	Risk Transfer	5 000 per 500 of each livestock/a
Crop Index Insurance	Risk Transfer	42 000 per 5x5km raster /a
TOTAL		23 330 512

Region	Total Cost in USD (for 31 years, incl. construction & maintenance)
AFAR Region	23 330 512
SOMALI Region	23 330 512
TOTAL	46 661 024

In this study, costs, maintenance costs, and parameterization were calculated in close cooperation with local and international experts to achieve a reduced uncertainty related to measures. Nevertheless, uncertainties remain when time-consuming modeling and engineering tools are not applied, and hence, the exact cost estimation of measures introduced into CLIMADA remains a challenge. The analysis thus renders moderate confidence concerning the costs of measures presented in this report, but can be updated and reassessed based on actually selected CCA measures to be implemented.

3.2 Cost-Benefit Analysis

Next, the existing relationship between costs (investment and maintenance) and net averted damage of a given measure is analyzed. As stated before the ECA framework estimates the benefit of adaptation measures based on their net averted damage.

An adaptation cost curve plots the benefit/cost ratio (Y- axis) against aggregated averted damages (X- axis) for each measure and hence illustrates averted damages per invested USD. The value one

(1) represents the threshold for the benefit/cost ratio, or in other words, values above it are cost-efficient while values below it are not. On the Y-axis, the larger a measure is, the larger the damage averted by it, therefore the larger the benefit or the mitigation or adaptation impact of a measure. Hence, with this figure, each measure can be analyzed in terms of damage mitigation/ adaptation efficiency and cost effectiveness and compared with one another.

Figure 5 and Figure 6 display impacts of measures applied to assets in Afar and Somali. Figure 7 and Figure 8 display respectively for Afar and Somali impacts of measures applied to persons as in 2050 under a moderate climate scenario.[13]

Grey measures, such as "riverbank restauration" or "improvement of water storage" are less efficient in terms of averted damage, but show a good cost/benefit ratio for each invested dollar. In Figure 6, for Somali, all measures are cost efficient, and account altogether to more than USD 1 000m of averted damage, if combined without overlapping effect and without insurance. These measures, although being cost efficient (i.e. having a benefit/cost ratio greater than 1), have a low adaptation/ mitigation impact (in terms of averted damage as measured by the width of the respective bars on the x-axis of the figures) with the notable exception of "communal seed bank" and "rehabilitation of irrigation system". Nevertheless, some of them could be considered in combination with others in order to reach combined objectives such as "seed bank" and "fodder tree and grass nursery sites".

Figure 7 and Figure 8 present the impact of measures on people in Afar and in Somali respectively. All measures, including insurance are beneficial, and account altogether to a reduction of more than 110 000 affected persons per invested 1 000 USD. It is noteworthy that the ranking of different measures is not necessarily different from the one observed previously for assets. It means that measures selected for assets have the potential to protect population at risk too.

Although similar, the results of the separate cost-benefit analyses are not the same in the two regions. While the same assumptions about cost of adaptation measures were made, the regions' respective portfolio of assets as well as the agro-ecological zones differ. For instance, the share of shrub land is much larger in Somali than it is in Afar while also the regions' average herd composition differ.

In the same line, the benefit/cost ratios are relatively high in both regions. This is mainly due to the strong economic and population growth in the regions, which makes investments made today very efficient when damages are increasing in the future. In addition, the most effective measures in the two regions are relatively cheaper than the others. In other studies and regions EbA measures are generally more cost efficient than traditional measures.

[13] As in all cases the total climate risk significantly surpasses the potentially averted damages or protected people it cannot be marked on the X-axis but is written into the respective figure in red.

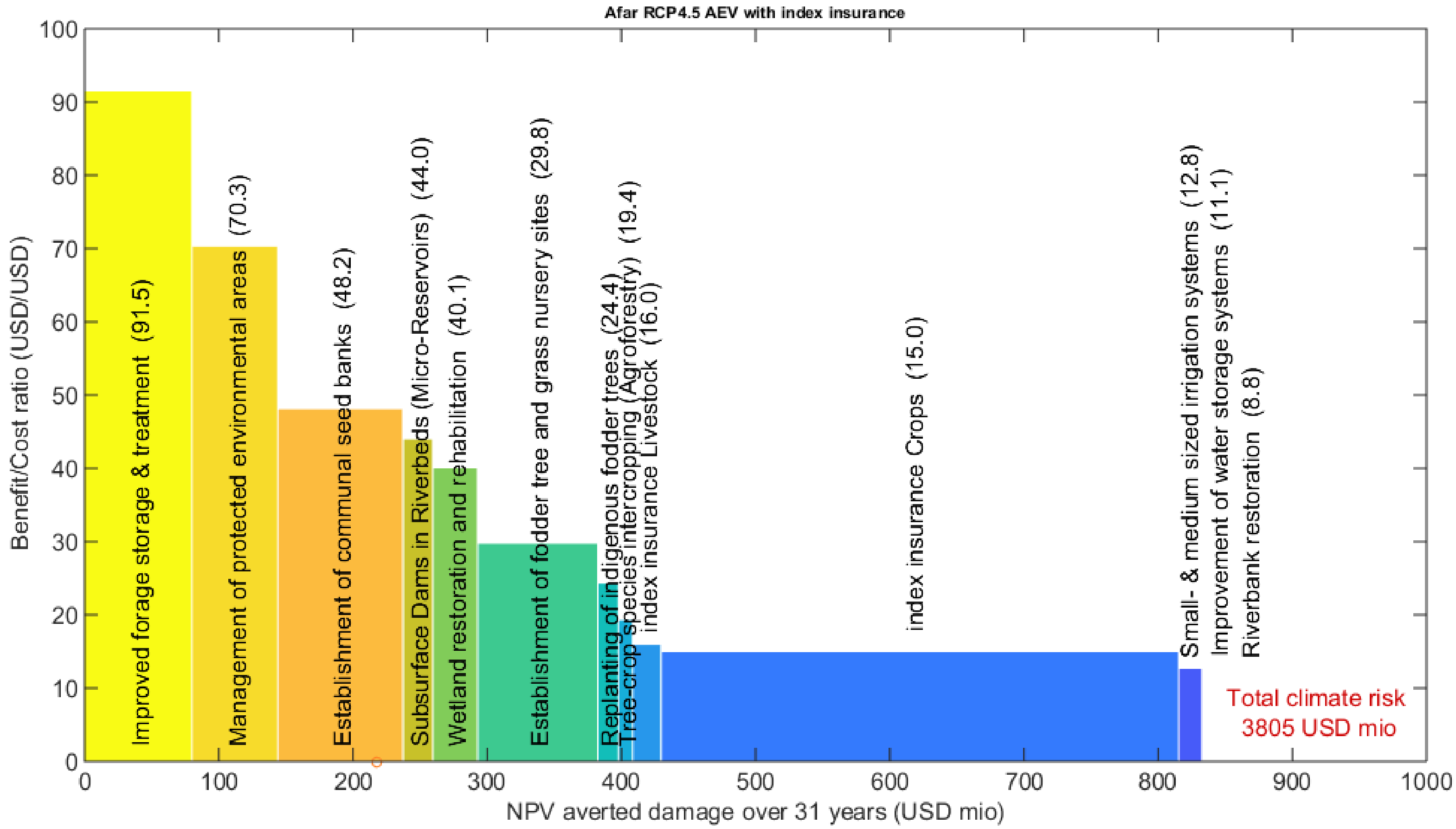

Figure 5: Adaptation cost curve for assets' damage for drought in USD for a moderate climate scenario (RCP4.5), AFAR

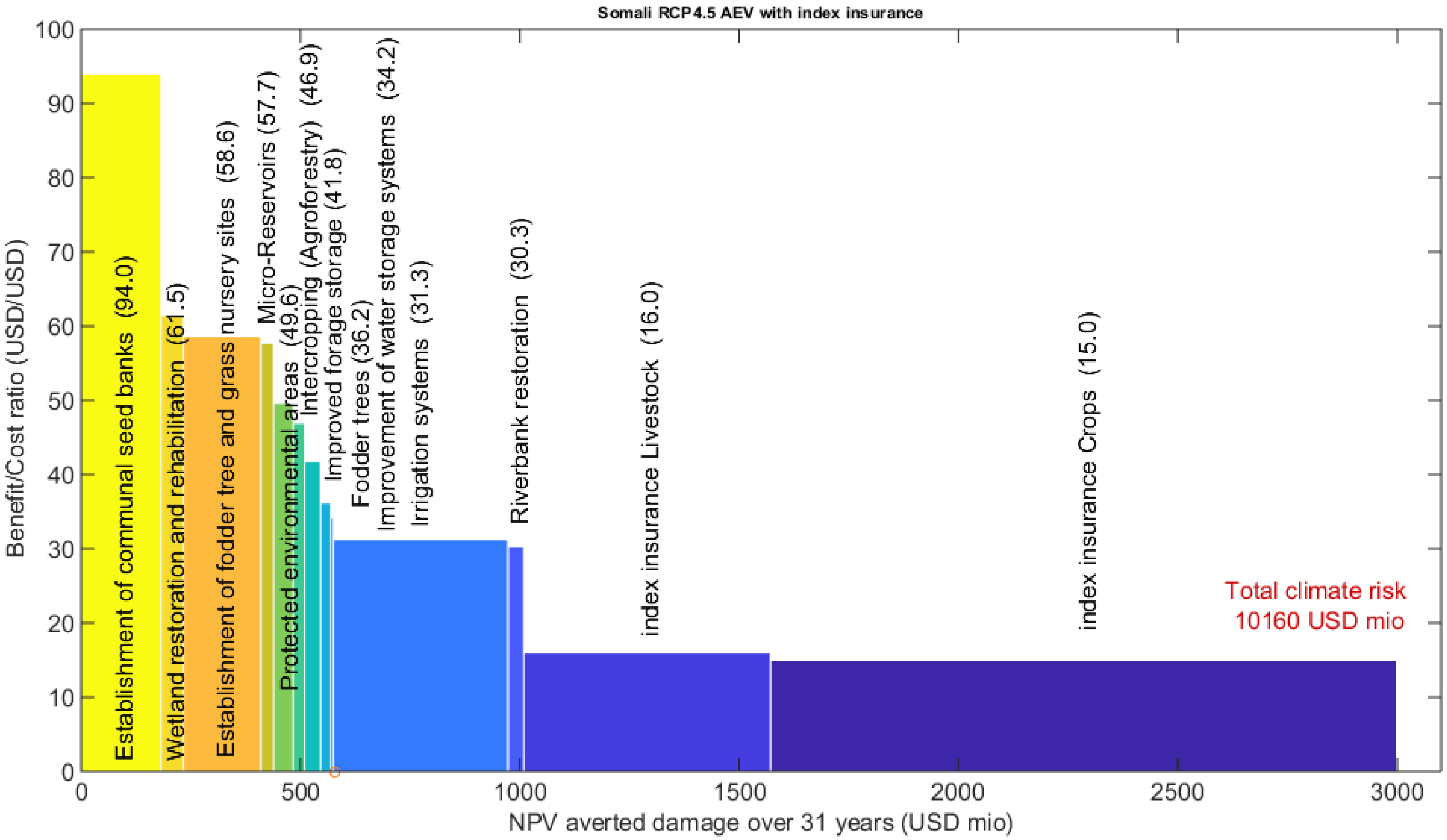

Figure 6: Adaptation cost curve for assets' damage for drought in USD for a moderate climate scenario (RCP4.5), SOMALI

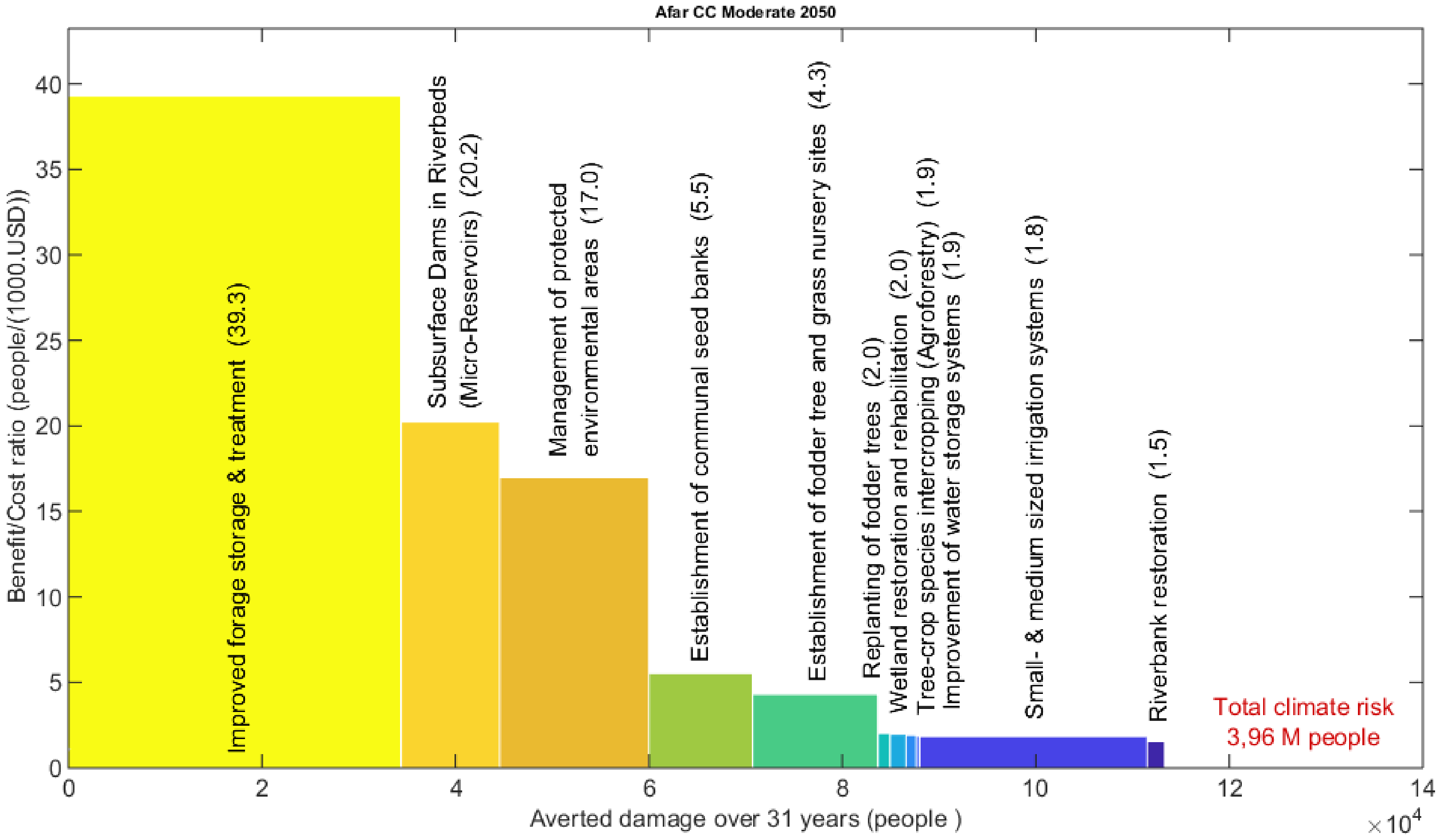

Figure 7: Adaptation cost curve for affected persons by drought for a moderate climate scenario (RCP4.5), AFAR

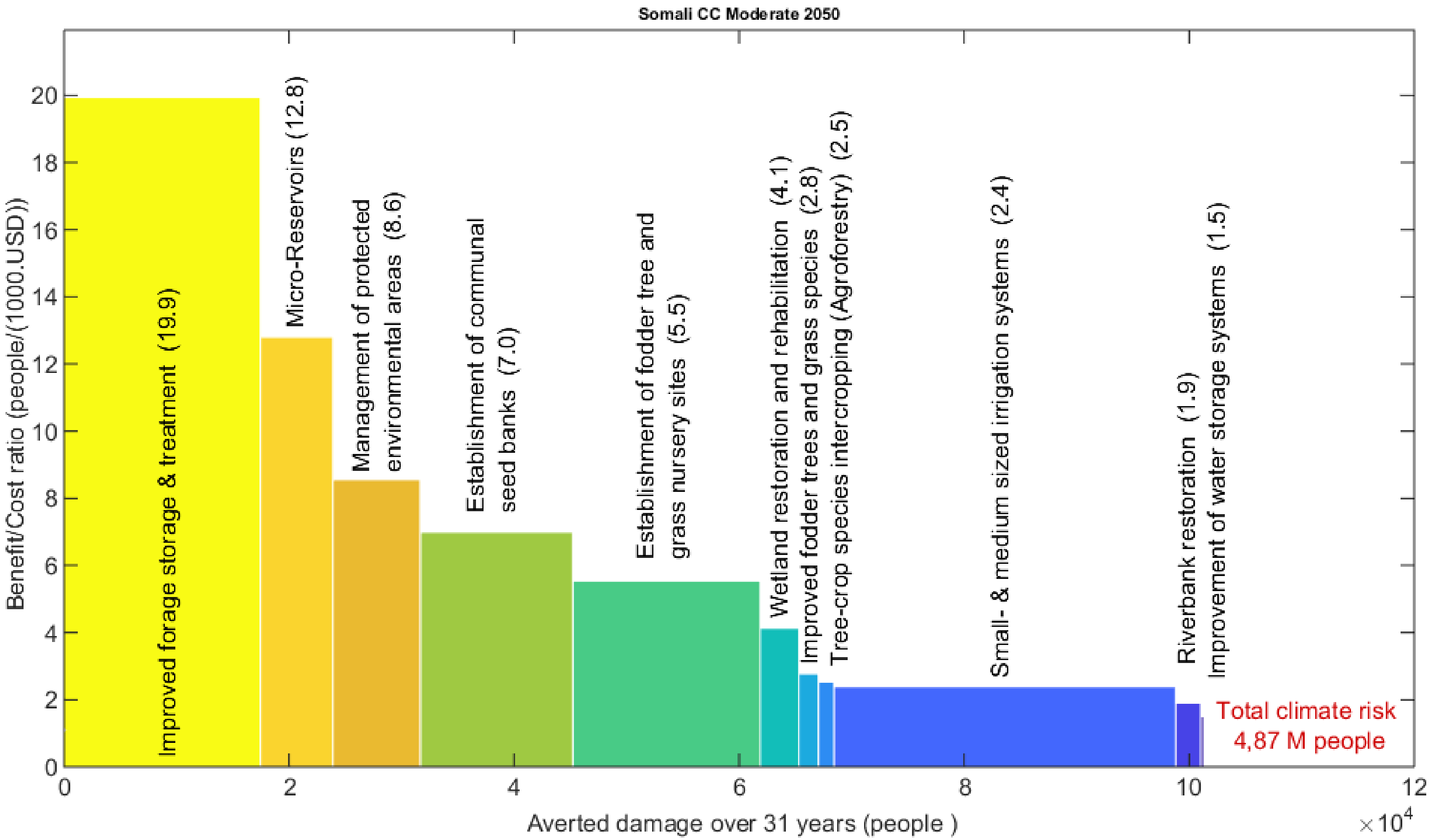

Figure 8: Adaptation cost curve for affected persons by drought for a moderate climate scenario (RCP4.5), SOMALI

3.3 Spatial Distribution of Benefits

The figures below showcase exemplary the spatial distribution of benefits on a given asset resulting from the respective measure as indicated. Due to limitations in the hazard resolution the highlighted areas of benefit are only indicative and not to be understood as exact locations. The benefits are presented as the annual averted damages averaged over the here relevant period of 31 years. In Figure 9, for instance, the benefits of the establishment of communal seedbanks, one of the most cost-efficient in both regions as identified above, on cattle in both regions is being displayed. Figure 10 displays the benefits of the most beneficial measure in the Afar region, Improved Forage Storage, for cattle (left) and shoats (right). A final example is shown in Figure 11 with the measure of Wetland Restauration and Rehabilitation for cattle (left), shoats (right), and vulnerable people (bottom) in the Somali region. Even though Wetland Restauration and Rehabilitation is only the 6th most beneficial measure with regard to vulnerable people in Somali this example showcases the additional benefits a measure can have although it may have been implemented targeting e.g. livestock rather than people.

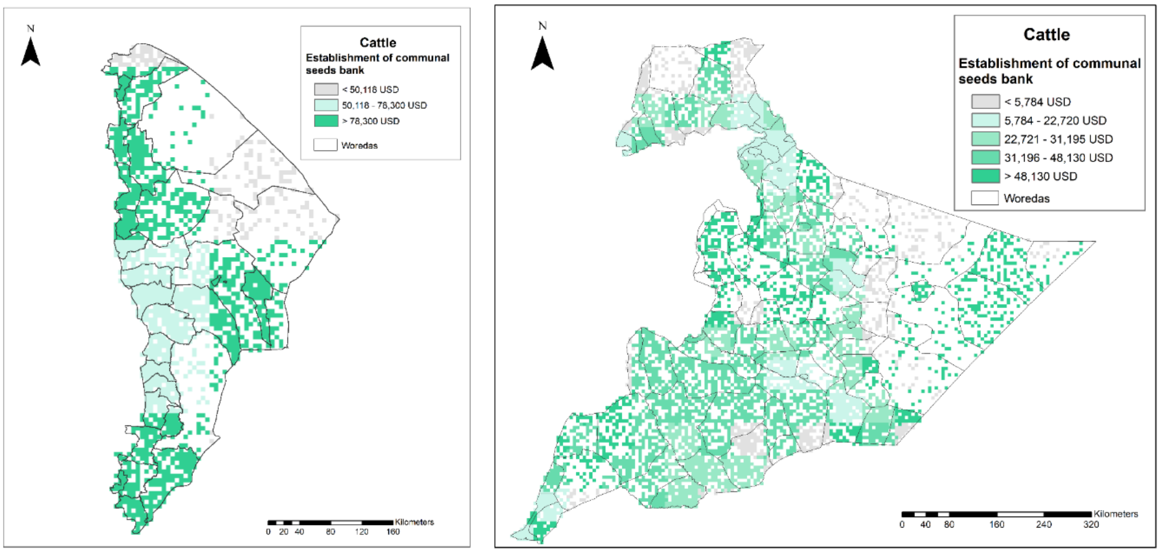

Figure 9: Benefits of 'Establishment of Communal Seed Banks' on cattle in Afar (left) and Somali (right)

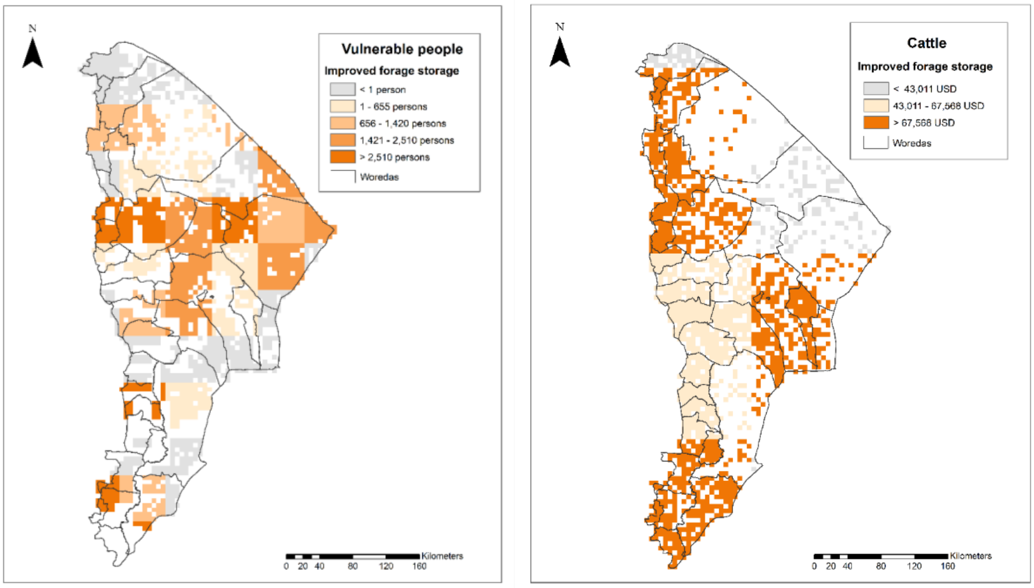

Figure 10: Benefits of 'Improved Forage Storage' in Afar on cattle (left) and shoats (right)

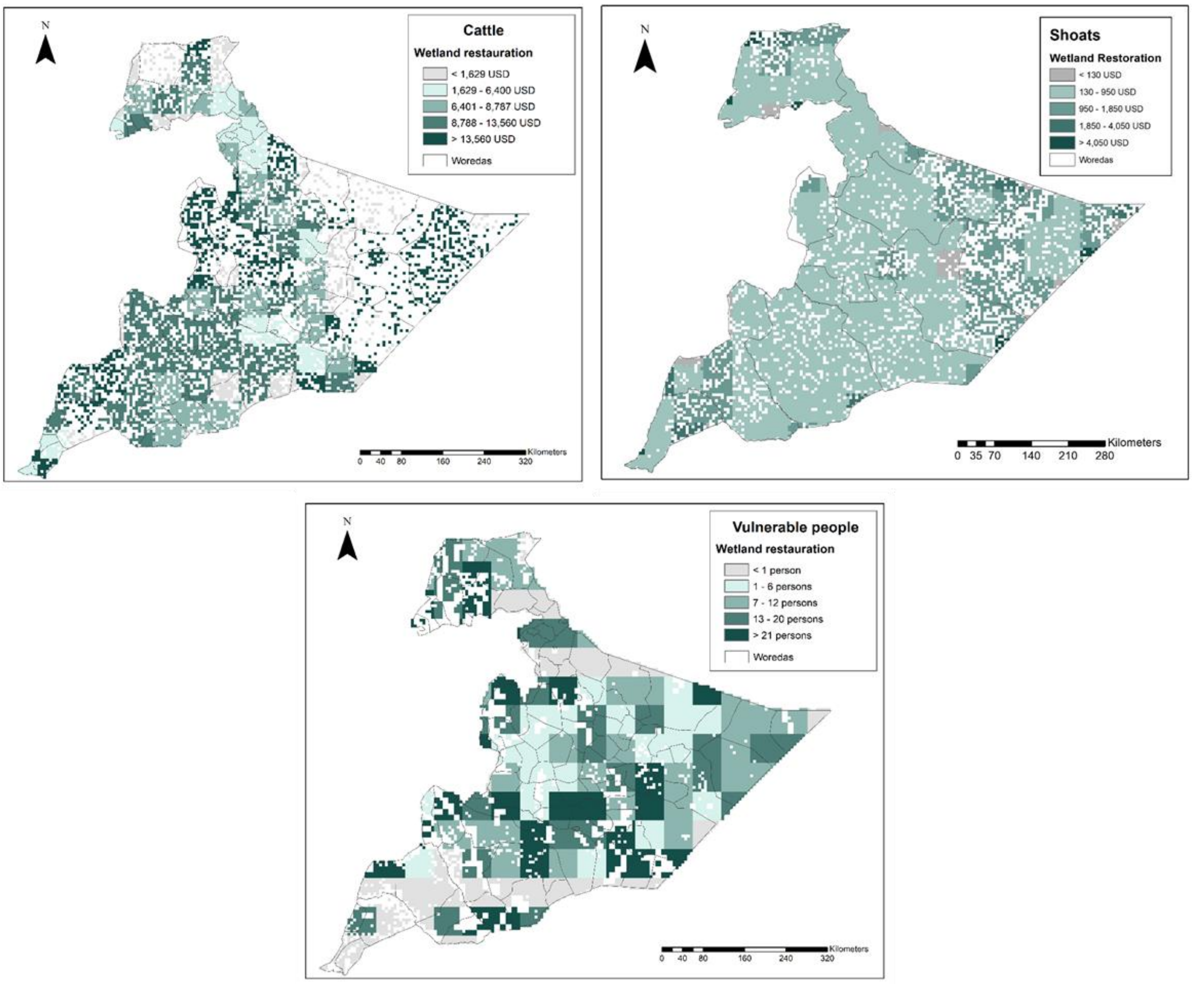

Figure 11: Benefits of 'Wetland Restauration' in Somali on cattle (top left), shoats (top right), and vulnerable people (bottom).

4 NEXT STEPS

Afar and Somali, as other arid areas in the world, are threatened by droughts and other extreme weather events. Along with growing populations and economies, losses from natural hazards are rising. In this report, we applied the Economics of Climate Adaptation, to integrate climate risk assessments and optimal adaptation solutions.

In its first part, this summary report recalls decisions made in coordination with all stakeholders regarding the scenarios (climatic and economic) to be applied and what assets should be considered in the analysis. During several workshops and webinars, a portfolio of measures (from a long list to a short list) have been discussed. Values have been validated by stakeholders' concertation and expert interviews.

Further, this report presents the results, assumptions and limitations of the development of a drought model for the region of Afar and Somali. The drought model developed for the purpose of this study provides unique improvement in resolution and quality to the simulation of drought in the region. Its integration into CLIMADA, the underlying modelling platform, provide an estimation of impacts of future drought risk impact for the selected assets. These results for future damages have been successfully validated against existing historical observations. By 2050, drought damages on the observed assets in Afar and Somali are expected to rise by more than fivefold and more than threefold for people, due to both, economic growth (assets will be more valuable) or population growths, and climate change (hazards will be more frequent and more intense).

Introducing a selection of adaptation measures provides insights for the development of a sound climate impact portfolio under the selected scenarios. Green measures and grey measures such as improved forage storage give the best return on investment while offering good protection against future climatic risks. These measures represent an investment of USD 10m and would take approximately two to five years to implement. These measures for the respective regions are listed below:

I. **Improved forage storage** (Afar), providing permanent structures constructed above ground and are commonly used in flat areas. For the Afar region, two concrete trench silos are planned. Each trench silo has a capacity of 2 000 tons.
II. **Management of protected areas** (Afar), involving exclosure favouring the recovery of woody species for 1000 ha.
III. **Establishment of communal seed banks** (Afar and Somali): It is planned to build communal seed banks where each has the capacity to store 4-6 tons of seed supply, covering at least 1200 households. In each region, 50 communal seed banks are planned (in total 100).
IV. **Wetland Restauration** (Somali) includes the restoration and management of wetland hydrology for the Ayisha & Shebelle basins. It includes also the improvement of agricultural practices and alternative livelihood options iand a better knowledge management and information sharing to facilitate community-based wetland restoration activities.
V. **Establishment of fodder tree and grass nursery** (Somali): Each nursery site should include the construction and rehabilitation of irrigation canals, water storage ponds to enable a permanent production of seedling and fodder seeds. It is intended to implement 100 ha of nurseries in Somali with 12 species and two types of germplasm.

These measures were evaluated at the pre-feasibility level and were considered technically feasible considering regulations, technological feasibility, location, resources, and sustainability. In addition to being cost-efficient, the measures also have co-benefits such as reduced adverse health effects, increased employment and productivity opportunities, and increased income. Potential negative effects have been also explored.

Economics of Climate Adaptation

Authors: Florian Waldschmidt, Alvaro Rojas, David Daou, Eike Behre, Teresa Arce Mojica, Preeti Koirala, Irafan Ullah, Zita Sebesvari, Sönke Kreft and Maxime Souvignet

Contributors: Annette Detken and Lena Laux

Design: Aileen Orate (UNU-EHS)

Prepared by

UNITED NATIONS UNIVERSITY

UNU-EHS

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