Decentralising Climate Funds (DCF)

Economic valuation of benefits from adaptation investments

A methodological note for assessment of returns on locally determined investments in adaptation to climate extremes and disasters in the region of Kaffrine, Senegal

Near East Foundation consortium under the Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) programme

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Executive summary

Anticipating and assessing returns on locally determined adaptation investments is challenging. Global and national support for adaptation can be disconnected from local realities. For communities living in environments that are prone to climatic extremes and disasters, priorities for resilience building may differ from those identified through global and national project preparation processes. Communities do not think of resilience building as one-off investment projects; they know it is a continuous process that requires consideration of economic returns on non-discrete, iterative adaptation investments. This is particularly so for adaptations that will work synergistically with local livelihoods and local peoples' own investments.

Vulnerable communities prioritise adaptations that are likely to bring immediate livelihood benefits and build resilience for the longer term. Investments in managing public goods – including land, water and social infrastructure – can increase economic productivity within the space of a season, while also conserving ecosystem processes that will continue to take effect over decades. Some of these effects can help to provide a buffer against the effects of climate extremes and disasters. Successfully enhancing public goods also brings many intangible social benefits. As a result, the total value of returns on locally prioritised adaptations over strategic planning horizons will eventually outweigh immediate increases in economic productivity. But effectively quantifying these long and short-term returns presents many methodological challenges and uncertainties.

A range of scientific methods are available to help assess some – but not all – of the economic value that can be anticipated from adaptation investments focusing on local public goods management. In this document, we present a methodology for assessing returns to the regional economy from locally prioritised adaptation investments through the DfID-funded Building resilience to climate extremes and disasters (BRACED) Decentralised climate finance (DCF) programme. This methodological note remains under discussion with DCF programme stakeholders, who are using a participatory approach in Senegal's Kaffrine region to prioritise adaptation investments with local decision makers and stakeholders.

Local actors in Kaffrine listed and prioritised investments in public goods that would help them build their resilience. DCF has implemented 75 of these interventions during 2016–17. As a first step in assessing the value of the returns on these investments, we propose a pilot *ex-ante* assessment to project future benefits that are anticipated on three scales:

- Individual field and village level (which will be of interest to households and communities)
- Regional level (which will be of interest to regional and national planners), and
- DCF portfolio of investments level in four selected departments (which will be of interest to stakeholders in international climate finance).

Although relevant planning timeframes range up to 2030, one and five-year timeframes are also important thresholds within which local stakeholders need benefits.

We intend to strengthen the rapid and simplified approach to *ex-ante* assessment of returns on DCF investments that we propose in this document through continued local consultation, coordination and field data collection. Building on this approach, we could also begin to consider developing an *ex-post* assessment to measure and monitor returns from projects that have been implemented over the past year (2016–17).

The iterative, consultative and participatory approach we are pursuing is essential to reflect planners' and local peoples' expectations and

assumptions around benefits for the region from complementarities and mutually reinforcing feedbacks between successful investments, strengthened local institutions and the broader portfolio of public and donor-funded investments for sustainable development.

It will be interesting to find out how returns on village-level investments in Kaffrine's marginal dryland area compare to adaptation investments in more humid and prosperous parts of the country and other parts of the world. We anticipate that our approach to the assessment of returns on locally prioritised investments may be of interest to regional, national and international development planners. The methods we recommend in this paper should help fill gaps in the existing economic profile and available planning documents for the Kaffrine region. We also encounter both strengths and weaknesses in statistical systems for monitoring and assessing the conditions and value of water and forest resources, and highlight some available methods to fill them.

Due to the complexity of factors associated with resilience building, we will only ever be able to make a partial economic assessment of returns on investments in adaptation. But the value of the partial returns we can assess from locally prioritised adaptation investments in Kaffrine may still outweigh any returns on centralised investments if the latter are implemented without effective decentralised planning and financing institutions.

Quantitative economic assessment of returns will always remain partial even in the event of a long-term retrospective *ex-post* assessment. But this should not prevent economic assessment of the benefits generated through both centralized and decentralized investment systems. We could also foresee increasing complementarities and mutually reinforcing feedbacks between strengthened local institutions, the decentralised investment system and the broader portfolio of public and donor-funded investments for sustainable development.

Contents

Executive summary ---- 3
Notes ---- 8
Acknowledgement ---- 8
1. Introduction ---- 9
1.1 The BRACED DCF project and participatory approach to local prioritisation ... 10
1.2 Intended application of methods for assessing returns on investments in DCF ... 11
1.3 Intended relevance of our methods beyond the DCF project ... 12
2. Overview: valuing adaptation in the drylands ---- 13
3. Context ---- 16
3.1 A changing climate prone to extremes and disasters ... 16
3.2 Adaptation priorities in DCF project communities ... 19
3.3 Projected future effects of climate change on Kaffrine's economy ... 20
4. Tools for participatory data collection ---- 22
4.1 Resilience assessment ... 22
4.2 Family portraits ... 23
4.3 Participatory geographic information systems ... 23
5. Quantifying physical processes, risks and effects ---- 24
5.1 Predicting future climate effects, extremes and disasters ... 24
5.2 Modelling the effects of climate change on water resource systems ... 28
5.3 Mapping land management, productivity and adaptations ... 31
6. Assessing the value of changes in goods and services ---- 36
6.1 Assessing the economic uses and value of water resources ... 36
6.2 Assessing forest production and fuel value ... 40
6.3 Assessing agricultural production and value ... 47
7. Predicting future economic returns ---- 51
7.1 Predicting the value of returns at individual investment level ... 52
7.2 Predicting the value of returns at a programme/portfolio level ... 53
7.3 Predicting the value of returns at regional level ... 55
8. Beyond the economic assessment of returns on investments ---- 56
9. Conclusion ---- 57
Bibliography ---- 58
Appendices ---- 64

List of figures, tables, boxes and photos

List of figures

Figure 1: Overview of methodological approach 10
Figure 2: Location of the Kaffrine region 11
Figure 3: Assessing the economic value of ecosystem-based adaptation to society 13
Figure 4: Assessing the value of returns on an adaptation investment assuming a single shock 14
Figure 5: Kaffrine: agroecological zones and administrative departments 16
Figure 6: Basins in Kaffrine 17
Figure 7: Rainfall trends in Kaffrine (1951–2011) 18
Figure 8: Temperature trends in Kaffrine (1992–2010) 18
Figure 9: Economic profiles for Kaffrine: 2011 and future projection without adaptation 20
Figure 10: Annual rainfall variability in Kaffrine and Koungheul 25
Figure 11: Dry spell frequency in Kaffrine and Koungheul (consecutive days with no rainfall) 26
Figure 12: Normalised rainfall departure at Koungheul station 27
Figure 13: Extreme wet characteristics recorded at Koungheul station 27
Figure 14: Household expenditure on livestock feed supplements and water during the dry season in Maodo Peulh 48
Figure 15: Three levels of interest for economic assessment in DCF 51
Figure 16: The devolved climate finance concept 54

List of tables

Table 1: Public goods investments in Kaffrine, as prioritised by local communities as prioritised by local communities, 2016-17 19
Table 2: Climate change scenarios identified by IED Afrique team 21
Table 3: Projected effects on productivity (Scenario 2) 21
Table 4: Techniques for resilience assessment 22
Table 5: Norms for human and livestock water consumption (global v Senegal) 30
Table 6: Assumptions about TLU (global v Senegal) 30
Table 7: Structure of a family herd in Maodo Peulh village, Koungheul 34
Table 8: Tropical livestock units in a family herd in Maodo Peulh village, Koungheul 34
Table 9: Goods and services with direct use value derived from adaptation investments involving water availability in the DCF project 37
Table 10: Benefits and potential valuation of water supply from DCF investment in Banjul Bante 38
Table 11: Range of forest products and value sources in and around Kaffrine 41
Table 12: Value of various products collected from forests in Kaffrine (2014) 42
Table 13: Costs (in US$) and inputs needed for establishing an agroforestry plot 44

Table 14: Annual costs (in US$) and inputs needed for plot maintenance/ recurrent activities 44
Table 15: Value of selected forest products using local and international market prices 45
Table 16: Rapid estimates of Net Present Value (r=2%) from 4 reforestation interventions in Kaffrine in FCFA 46
Table 17: Sale price of livestock in Maodo Peulh, by season 47
Table 18: Value of livestock production in Kaffrine (2011) 49
Table 19: Calculation of returns on investment 53

List of boxes

Box 1: Climate extremes observed by agriculturalist Moussa Ndao's family in Malem Hodar 24
Box 2: Climate extremes observed by livestock keeper Moussa Ka's family in Koungheul 25
Box 3: What is SWAT? 29
Box 4: Assumptions about water consumption 30
Box 5: Effects of agroforestry on crop yields 31
Box 6: Calculating the relationship between climate, grazing management and livestock production in the Ferlo (after Hein et al. 2009) 33
Box 7: Modelling the relationship between climate extremes and Rift Valley Fever in the Ferlo 35
Box 8: The value of a water supply in Banjul Bante village, Missira Wadene, Koungheul 38
Box 9: Basing the value of water on GDP 39
Box 10: The value of an extension to the water supply network in Kaffrine 40
Box 11: Forestry in Mbeuleup 43
Box 12: Restoring classified forest in Kaffrine 43
Box 13: The economics of agroforestry in Linguere 44
Box 14: Combined value of different forest products 45
Box 15: Rapid assessment of benefit streams from trees in reforestation projects (prepared by Vanja Westerberg, consultant) 46
Box 16: Accounting for livestock production in Kaffrine (2011) 49
Box 17: Benefits beyond economic valuation from improved water supply at Missira Wadene 56

List of photos

Photo 1: IED Afrique team during a workshop in Bamako, 2 June 2016 20
Photo 2: Water supply at Banjul Bante 38
Photo 3: Femmes Forestières, Kaffrine 43

Notes

Note on exchange rates

Unless otherwise specified, we use an approximated exchange rate where US$1 = 500 Central African CFA francs (FCFA).

Note on use of terms

In this document, we use the following terms, which are defined as in the OECD glossary of key terms in evaluation and Results Based Management (https://www.oecd.org/dac/evaluation/dcdndep/45810943.pdf):

Ex-Ante Evaluation: An evaluation that is performed before implementation of a development intervention.

Ex-Post Evaluation: Evaluation of a development intervention after it has been completed.

Note: It may be undertaken directly after or long after completion. The intention is to identify the factors of success or failure, to assess the sustainability of results and impacts, and to draw conclusions that may inform other interventions.

Acknowledgement

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1. Introduction

A number of studies have examined the costs of adaptation and the funds required to enable it (for exapmple in RdS 2014a). But the returns on adaptation investments intended to build resilience receive less attention and are sometimes more difficult to assess quantitatively. Decision makers need to weigh the costs and benefits of one investment option versus another. For some types of investment – such as large infrastructure construction – the methods needed for benefit/cost calculations are relatively well established (e.g. in IBRD 2010, Sartori *et al.* 2015, ADB 2017, IBRD 2013b). But for others – especially more local-scale investments that aim to build synergies with ongoing private investments and benefits to resource users – quantifying economic benefits to society can be more complicated.

In this document, we present concepts and methods for assessing the returns on locally prioritised adaptation investments. These methods can be used by planners and project managers to assess returns on investments in marginal dryland areas that are susceptible to climate extremes and disasters, such as the region of Kaffrine in Senegal. We hope that the concepts and methods presented in this document could be useful to inform regional planning. Assessing local adaptation investments could also help national and international decision-makers to understand local realities and decision-making.

This methodological note is a work in progress, intended to facilitate discussion among partners and stakeholders taking part in an initiative on building resilience to climate extremes and disasters (BRACED) funded by the UK Government Department for International Development (DfID). Some of the content may be useful as DfID prepares prepares to assess value for money achieved through its programme.

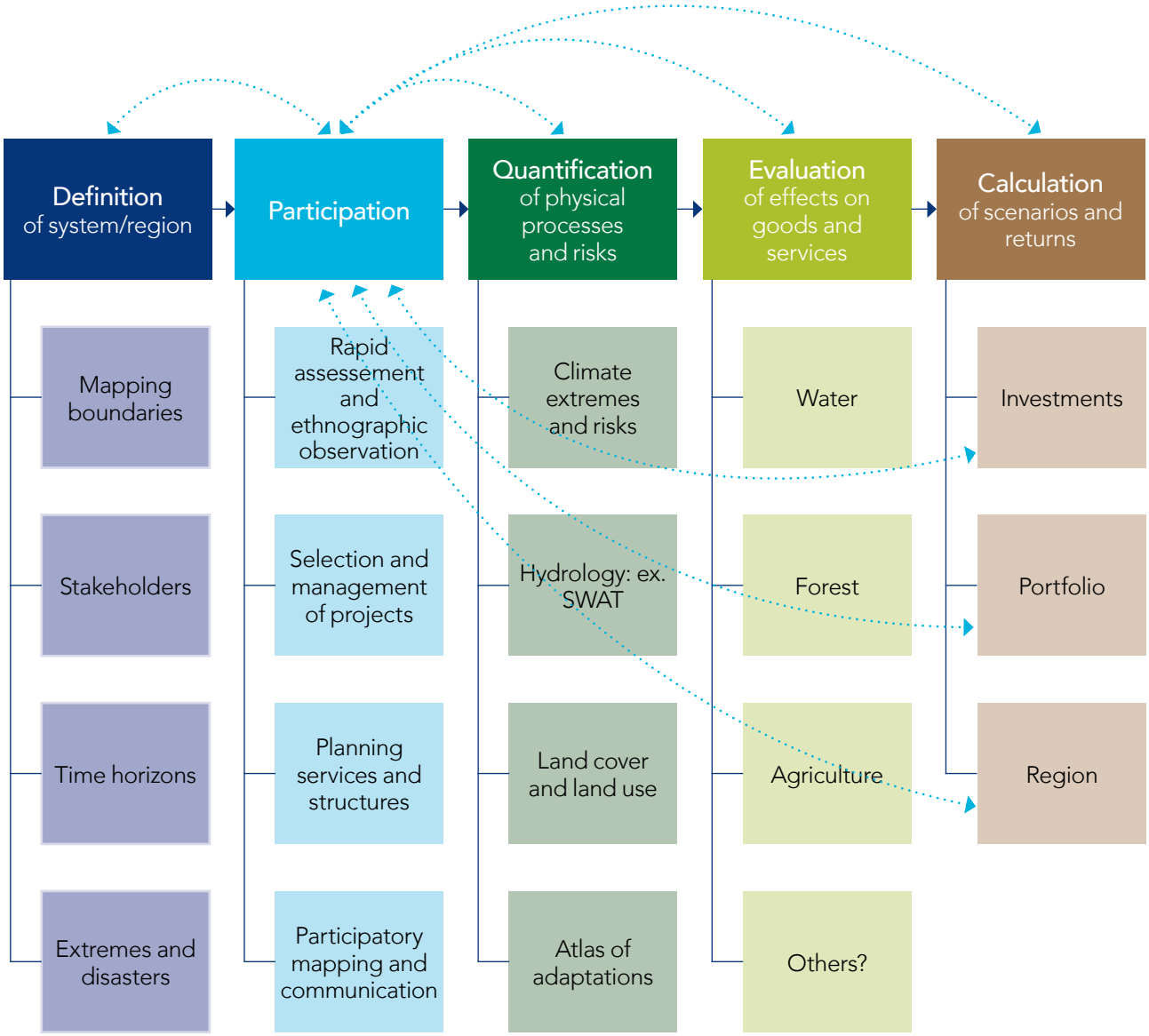
Our approach involves six major components, from defining the area of interest to calculating returns on investments (Figure 1). The methodological toolsets available to help along the way include participatory methods, quantitative methods for assessing environmental changes and risks and valuation methods for assessing the significance of these changes to the regional economy.

In the rest of Section 1, we describe the immediate intended use of this methodology. Section 2 is a short conceptual overview that lays out the global challenge to value returns on investments in adaptation to climate extremes and disasters in the drylands. Section 3 describes Senegal's Kaffrine region and the locally prioritised adaptation investments that have been made there. In Section 4, we describe the participatory aspects of our approach.

Scientific methods and tools available to quantify physical effects on natural resource conditions under changing scenarios for climate extremes and management conditions are presented in Section 5. We then explore how to place an economic value on the altered flow of goods and services to the regional economy in Section 6. Section 7 reflects on other considerations needed to generate qualitative and quantitative *ex-ante* assessments of returns on investments at project, portfolio and regional levels.

Before concluding, we discuss the limitations of economic assessments of returns on investments, since not all benefits from adaptation can be quantified and weighed in monetary terms.

Figure 1: Overview of methodological approach



1.1 The BRACED DCF project and participatory approach to local prioritisation

Through the BRACED programme, a team of non-governmental organisation (NGO) staff and researchers has established a decentralised climate finance (DCF) system in two regions of Senegal and Mali. The Near East Foundation (NEF) implements DCF with Innovation, Environnement et Développement Afrique (IED Afrique) and the International Institute for Environment and Development (IIED). The DCF project focuses on trialling a new approach to enable local stakeholders to access climate funds.

In Senegal, DCF has engaged with stakeholders to identify, prioritise, finance and implement local adaptation projects. These were distributed across four administrative departments – Koungheul, Kaffrine, Malem Hodar and Birkelane – which make up the administrative Kaffrine region (Figure 2).

Figure 2: Location of the Kaffrine region

Using a participatory approach, the project team in Kaffrine explored local experiences of climate extremes and disasters with decision makers and stakeholders from the region (summarised in Koulibaly 2017, Keita and Koulibaly 2017). This resulted in a listing and typology of local investments in public goods that local stakeholders considered necessary for building their resilience (see Appendix 1). These were selected and elaborated based on stakeholders' theories of the changes they expected to see from resilience-building interventions.

Investments focused on public goods to achieve non-excludable benefits for society as a whole. By and large, communities prioritised investments that would yield short-term improvements to their productive assets, while also building longer-term resilience, such as creating public infrastructure for market gardens, water points, cereal banks and irrigated rice production. Such investments contribute directly and quickly to household income generation and food security while also affecting resource conservation and migratory patterns, building institutions and having other longer-term effects.

1.2 Intended application of methods for assessing returns on investments in DCF

The DCF project aims to prove that decentralised investment systems offer a worthwhile complement to centralized finance systems. If DCF can show that decentralized finance provides value for money that is as good as – or better than – centralised planning and public finance systems, this will further strengthen its case.

Although the intended assessment of returns on the locally prioritized investments will probably raise many debates and questions, it is clear that:

- The key starting point for discussing returns on the DCF portfolio are the individual investments implemented by the local stakeholders - and the significant anticipated value of their achievements
- Returns on individual investments can and should be assessed quantitatively before they happen (ex-ante) and ideally also afterwards (ex-post), and:
- Exploring the value of returns on investments is likely to be stimulating, informative and a useful contribution to debates about the current planning system.

We intend the methods we propose in this note to enable the DCF team and other actors to conduct benefit-cost studies of investments in adaptation projects in the dry areas. They are a work in progress and are being refined through discussion and practical application, focusing on the value of individual investments to stakeholders in the region. This should ultimately help stakeholders advocate for further investments and upscaling and – more fundamentally – should help improve the design and performance of adaptation projects in particular and the environment and development projects more broadly.

Local prioritisation processes and stakeholder discussions involve weighing the benefits of each investment for the region. Although participants assess the relative value and ranking of possible investments to build resilience, at present, they do not necessarily quantify the value in detail. Stakeholders and the project team could use the methods we describe in this note to revisit the initial theories of change they discussed during project selection and to quantify the economic value of anticipated effects. Clarifying and quantifying assumptions made during the prioritisation process may help enable discussion and learning about the selection and performance of the investments.

Assessing economic returns on individual investments will be of interest to decision makers. But it will not necessarily represent a full assessment of returns on the overall DCF model. Developing a fuller picture of the DCF business case would require consideration of the added value of the decentralised approach, beyond the achievements of each investment. To do this, we would need to consider all costs – from start-up expenses to overheads and capacity building – of establishing a new system and ways of working.

1.3 Intended relevance of our methods beyond the DCF project

Although our primary concern is to assess benefits from locally prioritised investments, many of the methods we describe could apply to investments made through either decentralised or centralised investment systems. As such, they could enable users to identify contrasts and complementarities between these different approaches to adaptation planning and finance. This reflects regional planners' needs to consider the effects of the full range of investments that are taking place – not only those of individual donors or programmes.

The methods described in this note can feed into regional-level adaptation planning and to make use of datasets that are already part of the local and national planning systems. An assessment of returns on adaptation investments can begin from existing datasets with relatively little additional processing of information. But there are also many ways to further refine and strengthen assessments, depending on levels of interest and support from local and national decision makers.

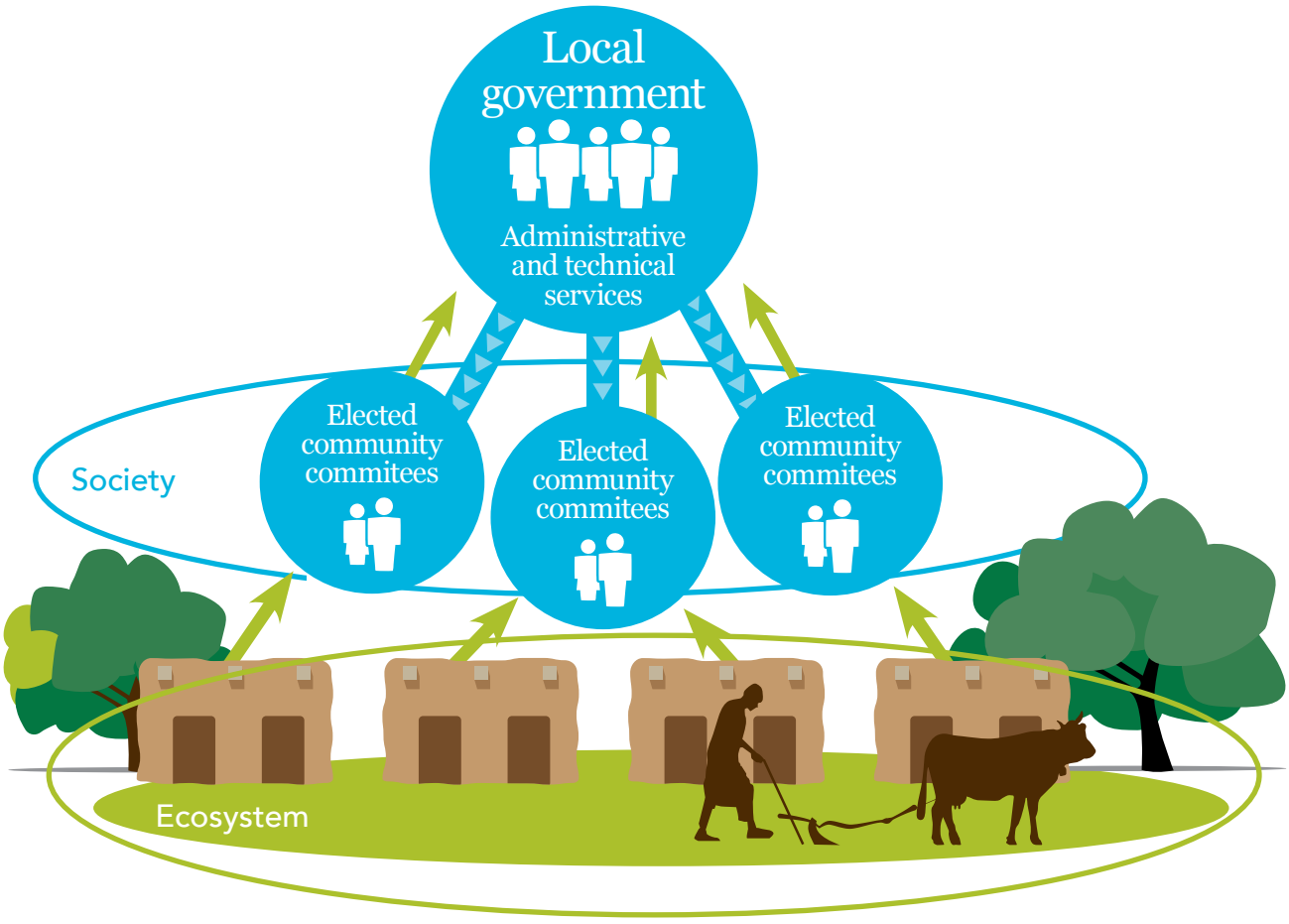
Our objective is not to propose a complex additional burden for planners and NGO staff that requires a large amount of expensive data collection. Rather, we hope to demonstrate how it is possible to integrate existing rapid participatory methods, decision support and statistical systems with readily available scientific tools such as geographic information systems (GIS) and remote sensing to generate quantitative assessments that are likely to interest decision makers. There will always be a need – or an opportunity – for further research and capacity building to improve the use of these methods, if decision-makers are willing to do so.

2. Overview: valuing adaptation in the drylands

The costs of action versus inaction on climate change have received significant international attention since the publication of the Stern Report (Stern 2006). The economics of adaptation and returns on adaptation investments are the other side of the penny (Chambwera *et al.* 2014, Trærup and Stephan 2014). But the value of these returns is more difficult to quantify than the investment budgets demanded by adaptation plans and detailed in adaptation project proposals (e.g. in RdS 2014a).

Available assessments of economic returns on adaptation investments focus on applying standard cost-benefit assessment approaches that are used in international financial institutions (e.g. ADB 2017, Sartori *et al.* 2015). Some of these assessments have been applied to climate change adaptation investments in dryland contexts (Watkiss *et al.* 2015, IFAD 2016, Vermeulen *et al.* 2016, Siedenburg 2016, Bond *et al.* 2017a, Bond *et al.* 2017b, Vardakoulias and Nicholles 2014), but most have focused only on assessing short-term benefits such as increases in agricultural productivity. They do not assess longer-term effects on society and the ecosystem processes that underpin their resilience (Figure 3).

Figure 3: Assessing the economic value of ecosystem-based adaptation to society



The Nairobi Work Programme (UNFCCC 2017) has identified a range of analytical tools for assessing the value of benefits from adaptation investments, including the ValuES platform (see www.aboutvalues.net) and a modelling approach called InVEST (Integrated valuation of environmental services and trade-offs) (Rosenthal *et al.* 2013, Lo 2016) that enables the valuation of a range of ecosystem services.

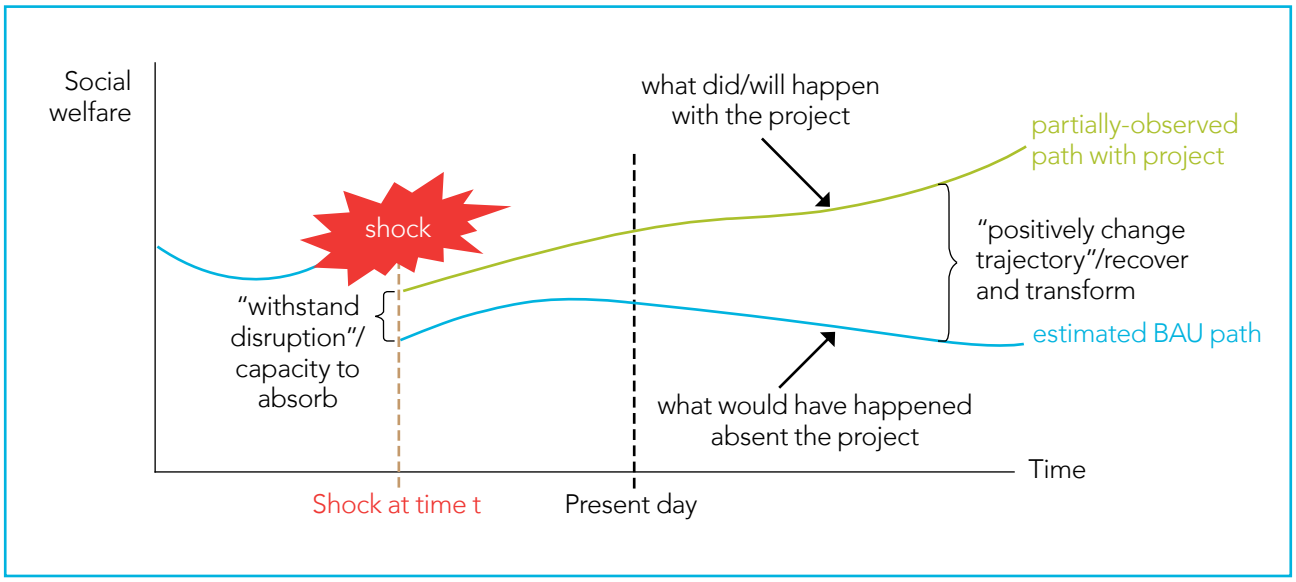
In the dryland context, assessing economic productivity is often complicated by the nature of services requiring valuation and the presence of various informal, undocumented economies. In many cases, national statistical systems fail to effectively record the productivity of a number of goods and services – such as the products from extensive livestock raising, natural heat, energy sources, outstanding spiritual beauty and other environmental services – that are most relevant and specific to dryland ecosystems and their populations.[1]

Another inherent problem with project-oriented cost-benefit assessments for all environments is that they seek to isolate and assess effects that can be attributed to a single project intervention (Figure 4). Although such effects are probably affected by a complex range of contextual factors, these factors must be excluded from the assessment – for example, through replication in an untreated control.

But building resilience is rarely an isolated, one-shot investment and climatic extremes and disasters are rarely discrete events distinct from longer-term processes. And although these challenges affect assessment design for all environments, in marginal drylands the cumulative effect of erratic drought and flood effects and their interactions with slower degradation processes are often considered a defining feature (Venton *et al.* 2012).

Additional related challenges arise in these contexts from the resulting 'boom and bust' drought and disaster economies (Hesse *et al.* 2013, Krätli and Jode 2015). The livelihood strategies of vulnerable people who repeatedly deplete and restock their capital assets can sometimes become dependent on external assistance and remittances or other forms of debilitating maladaptation

Figure 4: Assessing the value of returns on an adaptation investment assuming a single shock



Source: Bond et al. 2017

[1] For further discussion of underestimated economic value in the drylands, please see: www.iied.org/drylands-volatile-vibrant-under-valued

(Venton *et al.* 2012). This differs from contexts where it is possible to assess responses to a single shock or climatic extreme (Figure 4).

In efforts to differentiate between different forms of adaptation, available literature on disaster response differentiates between strategies to anticipate and absorb shocks and adaptation strategies that have a more transformative effect. Analyses of these strategies have distinguished between three As: anticipate, absorb and adapt.

One recent study (Tanner *et al.* 2015) has argued that investing in building resilience to extreme events and disasters through some or all three As can yield a triple dividend by:

- Avoiding losses when disaster strikes
- Unlocking development potential by stimulating innovation and bolstering economic activity in a context of reduced disaster-related background risk for investment, and
- Creating synergies of the social, environmental and economic co-benefits of disaster risk management investments, even if a disaster does not happen for many years.

An inherent challenge in any attempt to place an economic value on returns on adaptation investments or any other environmental or social phenomenon is that different people will make different judgements about their value. These judgements may reflect personal financial benefits or relate to subjective viewpoints and moral or cultural value systems. It is always difficult to reach a consensus on how society as a whole should attribute value. As a social decision, it is often contentious. An economic assessment of returns on investments should focus on returns to society as a whole. This is different from a financial assessment of returns on investments to private individuals.

We place a strong emphasis on a grounded participatory approach (after Chambwera *et al.* 2013, Lunduka, Bezabih and Chaudhury 2013) to identify the value of returns to society as a whole, coupled with state-of-the-art scientific methods and the progressive strengthening of national and international statistical systems (UN 2014). In line with ongoing climate change planning and scenario building at international and national levels (UNFCCC 2017), we hope this approach will follow up on previous efforts such as TACC (2013) and RdS (2014a) and feed into the domestication of planning scenario-building activities at regional and local levels.

Our approach draws on previous IIED work to establish a framework for assessing returns on adaptation investments in the drylands (King-Okumu 2015, King-Okumu 2017) and broader literature on the economics of land degradation and sustainable land management in the drylands (e.g. Bojo 1991, Sarraf, Larsen and Owaygen 2004, Sidibé, Myint and Westerberg 2014). This uses standard economic valuation approaches, including those that have been widely used to understand social returns on investment (SROI 2012) and the value of ecosystem services (TEEB 2011, Unai Pascual and Muradian 2010).

3. Context

3.1 A changing climate prone to extremes and disasters

Kaffrine is in central Senegal, in the southeastern corner of a larger savanna zone known as the Ferlo. In the region of Kaffrine, the land use changes from grazing agroecosystems in the north to forest and agricultural agroecosystems in the south (Figure 5). The southernmost part of the region is located in an area of Senegal that has been referred to as the groundnut basin. This zone also stretches beyond Kaffrine, across several regions.

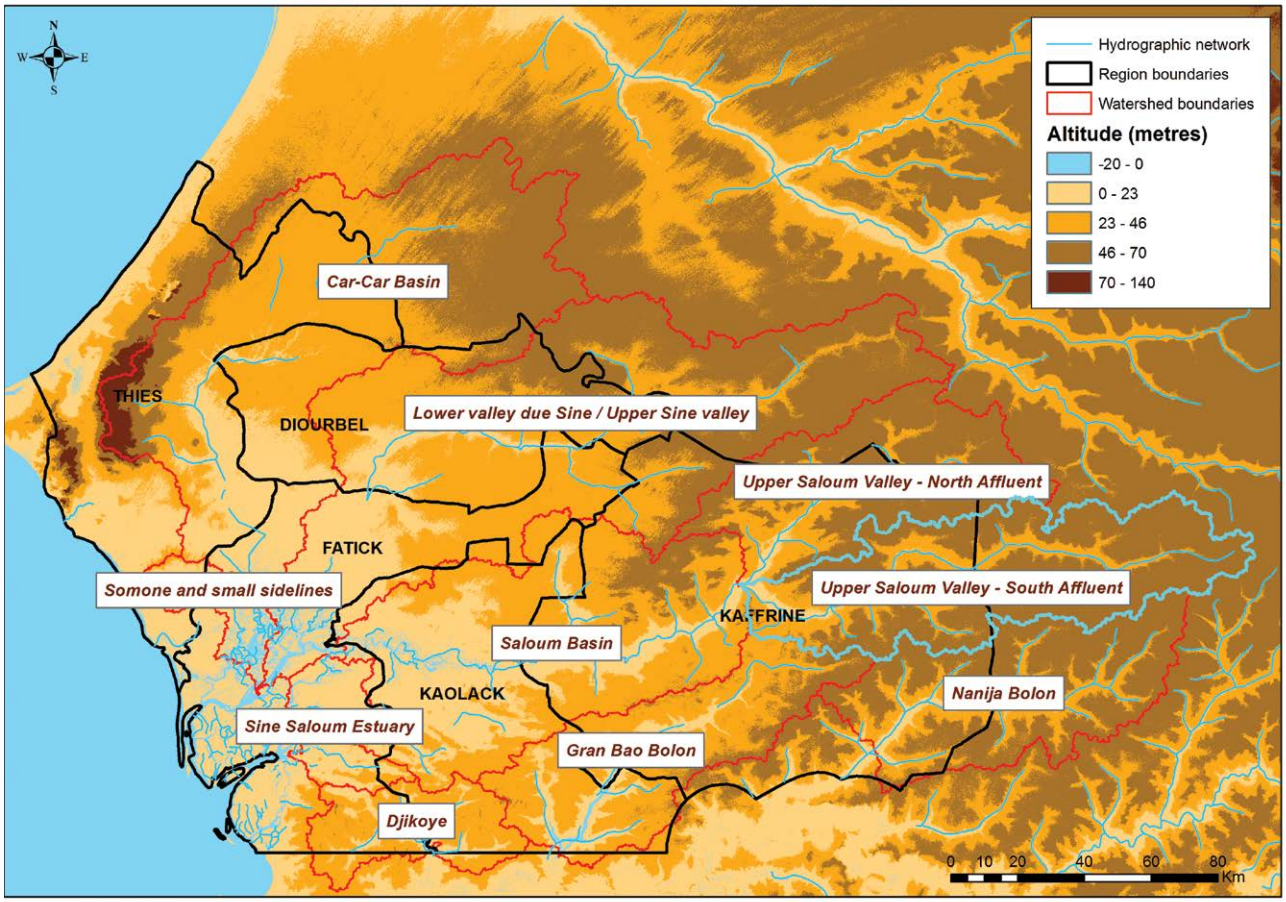
The two main surface water sources are the north extension of the hypersaline Saloum estuary and the Baobolong, a branch of the Gambia River that dries up downstream in the dry season (RdS 2014b) (Figure 6).

The Ferlo retains huge underground water potential (RdS 2014a) through a network of deep boreholes drilled during colonial times. There are four major aquifers in the Kaffrine region: the Continental Terminal (accessed via shallow wells up to 80m), the Eocene (Lutetian) (70–120m), the Paleocene (100–160m) and the Maestrichtian

Figure 5: Kaffrine: agroecological zones and administrative departments

Source: Ndao 2012, in TACC 2013

Figure 6: Basins in Kaffrine



Source: Based on DGPRE 2014

(250–450m). The Maestrichtian aquifer[2] feeds more than 70 deep boreholes drilled during colonial times (Le Houerou H. N. 1989). The water table is recharged by rainfall, the Senegal River and its branches.

The region is scattered with temporary pools (Soti *et al.* 2010). These provide water for livestock to drink and fishing opportunities in certain places. But a rainfall deficit and sand encroachment are causing premature contamination and the progressive disappearance of water points (RdS 2014b). And, although there is a map of temporary water points (RdS, 2014b), the volumes of water in the network are not well monitored. Nor is the changing water level, whether caused by climate changes or other anthropologic effects (see commentaries in Bodian *et al.*, 2016).

Land use systems in the Ferlo and groundnut basin include forests, pastures and croplands (FAO 2010a, King 2011). Land user groups include farming and pastoralist communities (Bradley and Grainger 2004). Their integration and coexistence depends on season, availability of natural resources and their ability to adapt to the changing seasonal patterns. On average, silvopastoral households own ten animals each, including cattle, sheep and small livestock (Ba *et al.* 2006). Crop production mainly consists of cereals (millet, sorghum, maize

[2] See more information in available studies: Travi, y., P. Pizard & M. Betton (1996) Temperatures and thermal gradients in the Senegalese Maastrichtian aquifer: simulated test on their effect on flow discharge. *Journal of Hydrology* 187, 333-350, Kane, C. H., M. Diene, M. Fall, B. Sarr & A. Thiam (2012) Reassessment of the Resources of a Deep Aquifer System under Physical and Chemical Constraints: The Maastrichtian Aquifer. *Journal of Water Resource and Protection*, 4, 217-223, Diéne, M., C. H. Kane, S. Faye, R. Malou & A. A. Tandia. 1999. Reévaluation des ressources d'un système aquifère profond sous contraintes physiques et chimiques : l'aquifère du Maastrichtien (Reassessment of deep aquifer system resources under physical and chemical constraints: the Maastrichtian aquifer). In *Proceedings Regional Aquifer Systems in Arid Zones – Managing non-renewable resources*, 82-92.

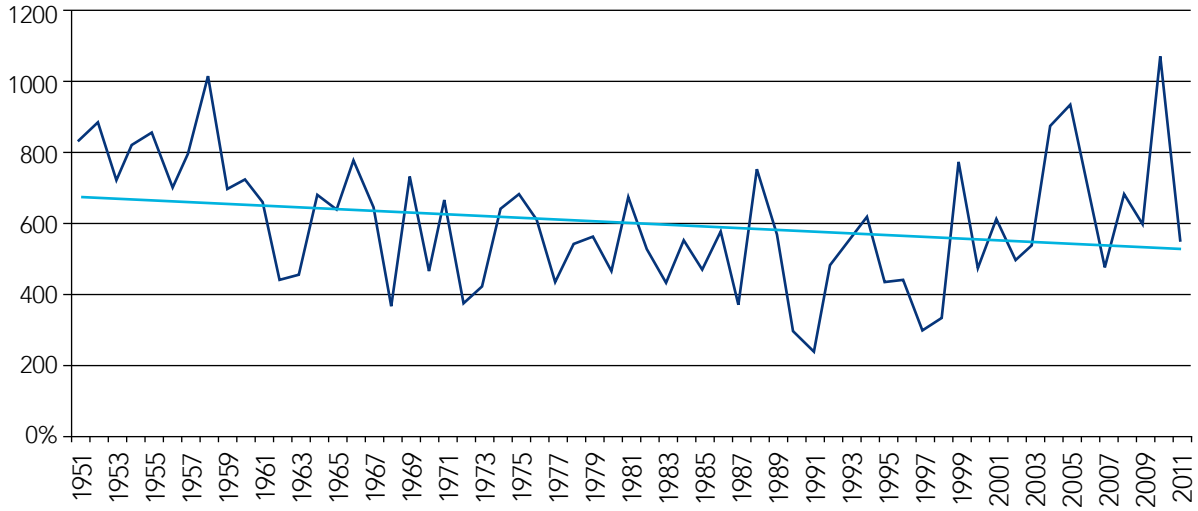
and rice), cotton, sesame and black-eyed peas (TACC 2013).

Planners in Kaffrine consider that climatic conditions are deteriorating (TACC 2013, 2014). Indeed, Figures 7 and 8 show that rainfall has been declining since the 1950s and temperatures rising since the 1990s. Various studies describe the damages associated with unmanaged or poorly managed climate change and variation (TACC 2014). Rainfall deficit and climate irregularities have varied the dates for the start and end of the winter season since the 1990s, affecting agricultural planning in the region (Hein *et al.* 2009; RdS 2014a).

Other notable impacts of climate change in the Ferlo have included: drying of the region and its valleys; lower water tables; water and wind erosion; soil degradation; and land salinisation (RdS 2015a). Bush fires are a hazard during the dry season, while flooding causes large-scale destruction in the rainy season.[3]

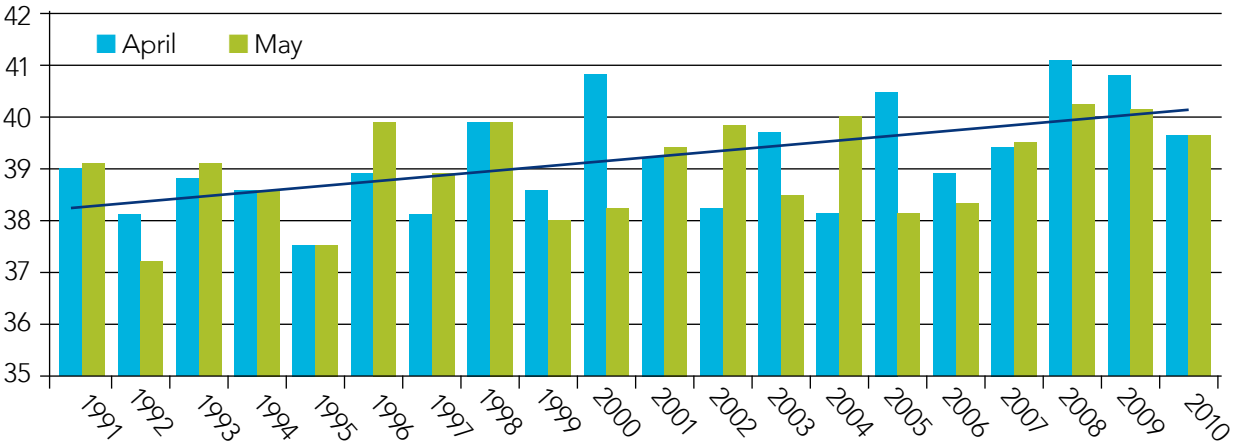
Drought is a recurrent extreme event and disaster in Kaffrine and across the surrounding Sahel region. Regional droughts cause in-migration of pastoralists towards the Senegalese Ferlo. This magnifies the pressure on resources and people in the host region of Kaffrine.

Figure 7: Rainfall trends in Kaffrine (1951–2011)



Source: ANACIM 2012, cited in TACC 2013

Figure 8: Temperature trends in Kaffrine (1992–2010)



Source: ANACIM 2012, cited in TACC 2013

[3] See: www.braced.org/reality-of-resilience/i/?id=9e43dee4-ddbb-4b9a-a96e-034177dc7077

3.2 Adaptation priorities in DCF project communities

Between 2016 and 2017, DCF has financed 75 locally prioritised investments for adaptation to climatic extremes in Kaffrine (see Table 1 and Appendix). In light of the nature of the extremes – which include drought, flood and forest fires – a high proportion (35 per cent) of the selected projects are directly concerned with water management (highlighted blue in Table 1). Many of the remaining 65 per cent of activities also need water supplies to be maintained at times of drought or flood. For example, livestock production and school improvement interventions do not target access to water, since this may already be secured through other projects. But the value of these interventions depends to a large degree on the availability of water supplies.

The theories of change for each of the projects include complex sets of benefits anticipated to contribute to achieving resilience over both the short and longer term. These theories often assume that benefits of one kind will lead to another – for example, improved access to drinking water will lead to improved health and reduced workloads for girls and boys, which in turn will enable them to spend more time in school. There are also some benefits that increase flexibility and choice in the case of climate extremes and disasters – for example, while a village water supply can improve access to water for livestock, in case of a forest fire the water will be available also for firefighting.

Among the anticipated benefits, some have an easily recognisable economic value. For example, as well as contributing to household access to drinking water, water supply and sanitation projects can also improve or create economic activities such as market gardening, raising livestock and producing tree seedlings for reforestation. In fact, there are often overlaps between benefits from different project types.

For households, the economics of adaptation involves increasing income while also avoiding expenditure and loss. By avoiding the loss of productive time and energy, women, men and young people find they have time for other activities, such as study. The exact nature of these benefits to individual households will depend on their budget, seasonal calendar and daily routine. But these are financial values. Converting them to economic values requires us to consider effects on society and the economy, rather than individual households.

Table 1: Public goods investments in Kaffrine, as prioritised by local communities as prioritised by local communities, 2016-17

Investment type*	Number (total 75)	% of all investments
Water and sanitation	16	21
Market gardening (irrigated)	4	5
Reforestation (seedlings irrigated)	7	9
Livestock production (pathways, vaccination centres)	12	16
Transformation of agricultural produce	9	12
Grain storage	16	21
Schools	8	11
New energy sources	3	4
Total	75	100

*Blue shading denotes investments that are directly dependent on water availability – from rainfall or stored rainwater

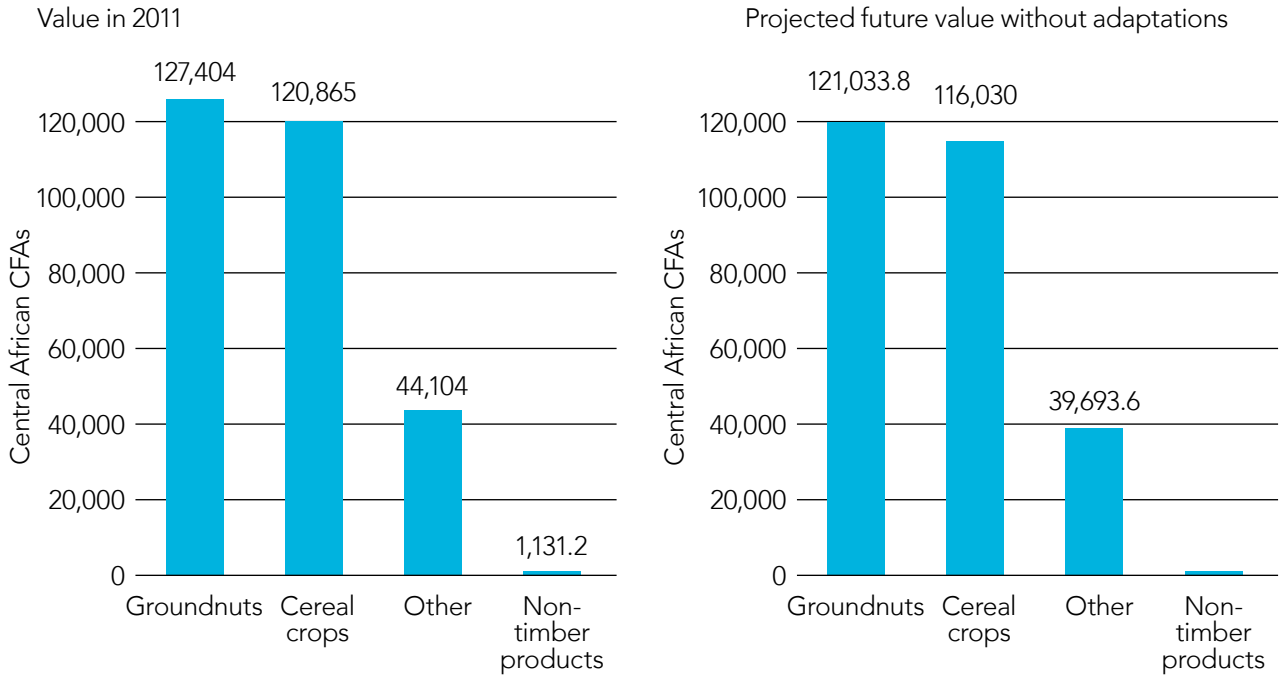
3.3 Projected future effects of climate change on Kaffrine's economy

After a series of participatory workshops in 2016 in Kaffrine, members of the DCF team (see Photo 1) sketched a rough profile of the region's economy and developed a hypothetical profile of its future without adaptations (Figure 9). This was relatively similar to an economic profile for the region previously developed by the regional technical services (TACC 2013).

The existing regional profile (TACC 2013, IREF 2014) was based on available agricultural production statistics for 2011, data that are also reflected in the Regional integrated development plan (RdS 2013a, RdS 2013b) and the Integrated territorial climate plan (RdS 2014a).

Photo 1: IED Afrique team during a workshop in Bamako, 2 June 2016. (From left to right: Djibril Diop, Momath Talla Ndao, Lancelot Soumelong and Papa Coulibaly). Caroline King-Okumu

Figure 9: Economic profiles for Kaffrine: 2011 and future projection without adaptation



To project the economy of Kaffrine in a future without adaptations, the team identified a baseline year for comparison and three possible future scenarios (see Table 2). They then used Scenario 2 to calculate the effects of climate change (Table 3).

It is notable that the existing economic profile and scenarios do not consider the effects of climate change, extremes and disasters on public goods such as water resources. The profile does not attribute value to public infrastructure, health, amenities or the pasture lands that support livestock production and wildlife resources. And, although it does consider forest production, it gives it a low value compared to crop production.

In contrast, local resilience assessments and locally prioritised adaptation interventions underline the value of these goods and services for resilience building. These values need to be better captured in the regional economic profile and planning scenarios. Not only could this enable a better understanding of the costs associated with climate extremes and disasters, it could also clarify the economic value and difference that we can expect from locally prioritised adaptation investments.

Table 2: Climate change scenarios identified by IED Afrique team

Scenario 1	Scenario 2	Scenario 3
A hot, dry climate marked by a rise in temperatures and an accumulated reduction in rainfall. Rainfall deficit is a real problem.	A very variable climate, with alternating wet and dry years. Temperatures rise significantly and extreme events – such as floods, heatwaves, droughts and dry season rainfall – are more frequent and more intense.	A wetter and hotter climate, characterised by a return to generally favourable rainfall conditions.

Source: (RdS 2014a)

Table 3: Projected effects on productivity (Scenario 2)

Crop	Groundnut	Cereal crops	Other crops	Non-timber products
Reduced by	5%	4%		2%
Increased by			10%	
Projected economic value	121,034	116,030	48,208	1,108

Source: TACC (2014)

4. Tools for participatory data collection

Participatory methods are central to our approach. The DCF project examines returns on investments that community members have helped select, implement and monitor. Using tools from a standard toolbox of participatory field research methods,[4] can help to collect data on the condition of natural resources in Kaffrine and anticipated returns on adaptation investments.

The key participatory tools and methods used in the DCF programme are:

- Resilience assessment
- Family portraits
- Participatory mapping

These are each described briefly in this section.

4.1 Resilience assessment

IIED has developed and applied a participatory approach to assessing resilience. Previously applied in Mali and other countries (Keita and Koulibaly 2016), it uses a series of participatory appraisal techniques during facilitated public meetings (Table 4). In Senegal, IED-Afrique has streamlined this approach into two main tools:

Table 4: Techniques for resilience assessment

Tools	Objectives	Facilitated plenary discussions
Tools 1a and 1b: Assessment of wellbeing and livelihood asset systems	Understand the criteria and categories of wellbeing, how changes are produced and livelihood types	Brainstorming and questions-and-answers to define and qualify terms relating to wellbeing and how it evolves
Tool 2: Construction of livelihood asset systems	Establish livelihood systems Identify the basic elements of different systems and the factors that determine vulnerability and resilience	Group work and reports to plenary to identify elements of the system, how it is constructed and interdependence of elements
Tool 3: Seasonal calendar	Describe characteristics of different seasons and their impacts on livelihood assets during normal or drought periods Explore the nature and logic of different strategies and actions used to anticipate, absorb and adapt to seasonal dynamics and climatic extremes Enable understanding of how community planning integrates variability	Group work and reports to plenary to identify difference between the seasons and strategies. Table format to separate different types of climate extremes and strategies
Tool 4: Resilience scale	Evaluate the relative levels of resilience of different groups Identify key factors that determine resilience	Brainstorming, questions and answers Group work and restitution
Tool 5: Theory of change	Enable understanding of how resilience could be reinforced and what processes enable a household to become more resilient Identify three or four possible entry points together with indicators to show the improvements.	Group work, report to plenary and questions and answers to identify three to four priority actions, schematise anticipated effects, etc
Tool 6: Identifying interventions	Identify interventions necessary to cope with constraints that weaken livelihood strategies to improve resilience	
Tool 7: Prioritisation	Enable understanding of the interventions the community prioritises Produce a classification that can be used for planning	

Source: Based on Keita and Koulibaly (2016)

[4] See: www.iied.org/participatory-learning-action-pla

A **vulnerability matrix** measures the exposure of resources and production systems to climate risks. It uses a scoring system to capture the level of sensitivity of resources and means of survival in relation to the risks. The scores are averaged to arrive at an impact and an exposure index.

A **participatory diagnostic framework** is a table that enables us to identify resources, sectors and vulnerabilities in each agroecological zone. It also characterises solutions, prioritising them for intervention.

These tools are designed for stakeholders to use in public meetings. They work best when there is a skilled facilitator who can communicate in local languages and ensure that all participants feel able to contribute to the discussion. The DCF project used these tools to prepare local stakeholders in Kaffrine to identify and select adaptation investments.

4.2 Family portraits[5]

To use this ethnographic observation method, researchers select a household that is representative of certain characteristics. The selection can take place at a village meeting to give community members the opportunity to discuss and agree the choice of selected family.

The DCF project has applied this approach to identify households representing different productive sectors in Kaffrine. Selected families must be willing to receive a study team in their home for four days and to collaborate with the study team so they can collect as much information as possible for the study.

The team compiles all of the information and reviews it with the family so that they can validate the findings before the study is finalised.

4.3 Participatory geographic information systems

Participatory mapping techniques are a standard element of the participatory appraisal toolbox. Participatory GIS encourages groups of resource users to use digital maps to record and label the location of resources that are of interest to them. Community members can also use smartphones to log and share resource locations to populate digital maps.

Free downloadable software makes participatory resource mapping more accessible for resource users. These include OpenStreetMap[6], which is useful for recording the location of resources and QGIS[7], which is useful for developing maps that can be labelled and shared as finished products.

[5] For more on family portraits, see www.policy-powertools.org/Tools/Understanding/docs/family_portraits_tool_english.pdf
[6] https://www.openstreetmap.org/about
[7] https://www.qgis.org/en/site/

5. Quantifying physical processes, risks and effects

In this section, we outline available methods for assessing the physical risks and effects of climate extremes and disasters. We also begin to consider the differences that adaptation investments can make to biophysical processes.

We anticipate that the methods we describe in this section will connect to and be guided by the participatory approach we described in Section 4.

5.1 Predicting future climate effects, extremes and disasters

At the regional level across the Ferlo and the groundnut basin, planners have observed decreasing rainfall, rising temperatures and increased occurrence of climatic extremes (see Section 3 and TACC 2013, DGPRE 2014).

Recollections and observations from local communities can help us assess the specific nature, occurrence and significance of climate extremes against which communities must build resilience. The DCF team collected information from local communities during a series of workshops in 2016 to assess local-level resilience strategies. These strategies were then explored further through in-depth interviews with selected households (Boxes 1 and 2) and by comparing local and regional meteorological information (Figures 10–13).

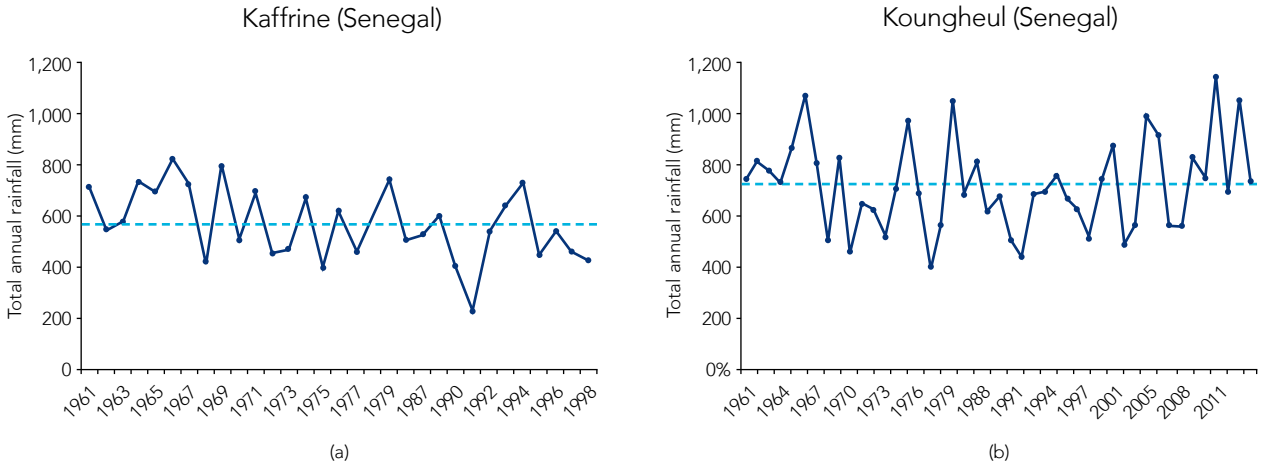
Box 1: Climate extremes observed by agriculturalist Moussa Ndao's family in Malem Hodar

1952	Famine
1962	Famine
1963	Flood
1987	Fire: one death recorded (household head)
1987	Locust invasion: loss of harvests
1998	Flood: loss of harvests and seeds
2007	Flood: loss of all stores
2011	High winds
2015	Heatwave: loss of life (son); loss of livestock (horse)
2015	Flood: loss of 150 stores, including two in the household
2016	High winds
2016	Drought

Box 2: Climate extremes observed by livestock keeper Moussa Ka's family in Koungheul

1973	Drought and famine: insufficient pasture and livestock deaths; family migrated toward Ribot Escale to graze and water their livestock, selling some animals to buy food and feed supplements from the livestock services in Ribot Escale
1985	Irregular rains: poor harvest; sold some livestock to buy food and livestock feeds
1988	Heavy rains: poor harvests and loss of crops; family sold livestock to buy wheat because rice was too expensive
1991	Migration of rural community to Koungkoung for a season; abandonment of land for a season due to a marabout[8] Mbacké-Mbacké
1995	Yellow fever epidemic: loss of life (three family members), which slowed down social and economic activities. The family accessed health services
2001	Rains out of season: loss of livestock
2004	Flooding and high winds: loss of livestock
2015	Poor rains and reduced pasture availability: migration toward Djolof, northern Senegal, in search of other pastures

Figure 10: Annual rainfall variability in Kaffrine and Koungheul

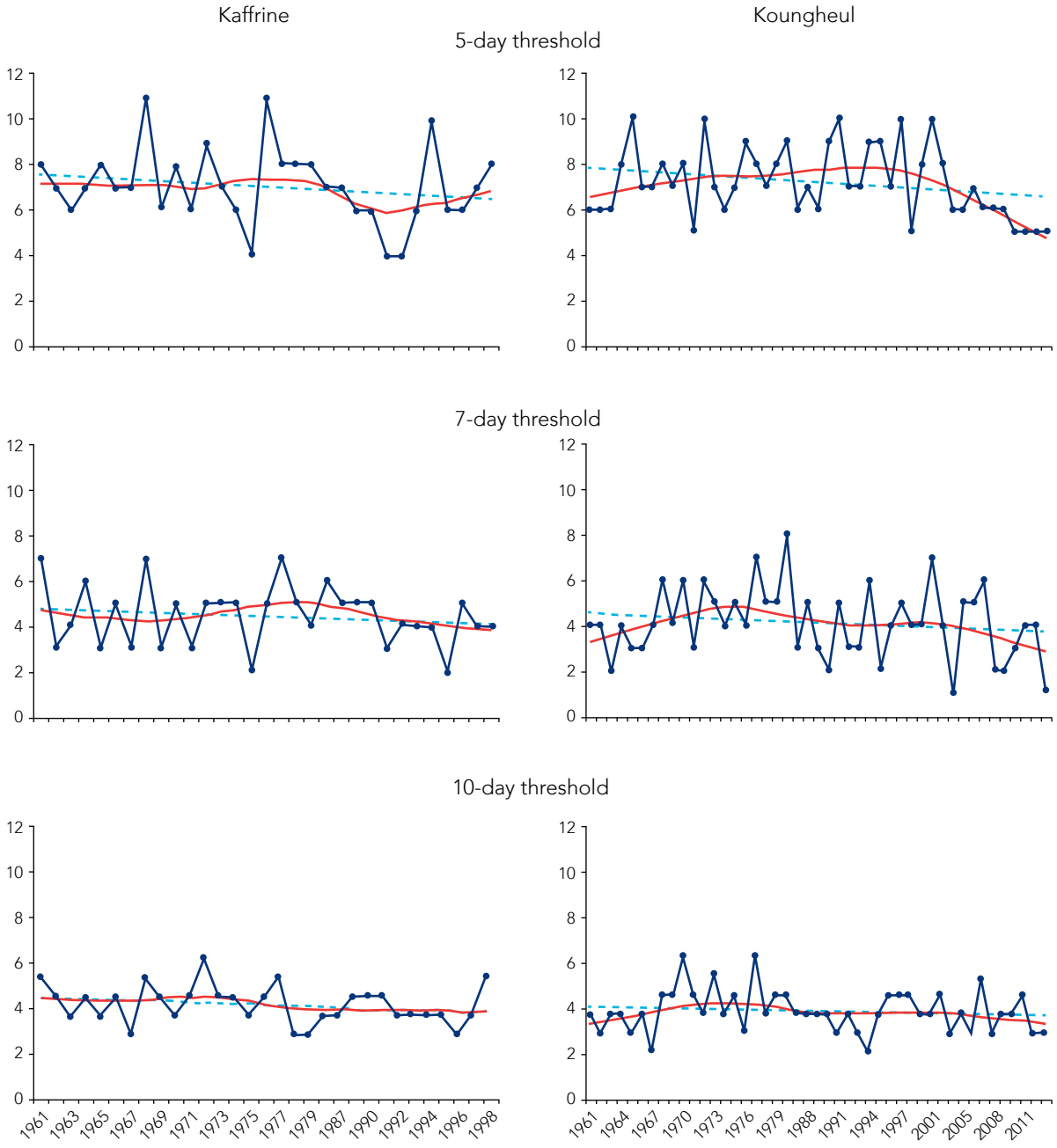


The horizontal dash line indicates the long-term (1961–1980; 1987–2013) average of the annual rainfall total.
Data from 1981–1986, 1999 and 2003 seasons are not available.

Source: Cornforth and Lélé (2014)

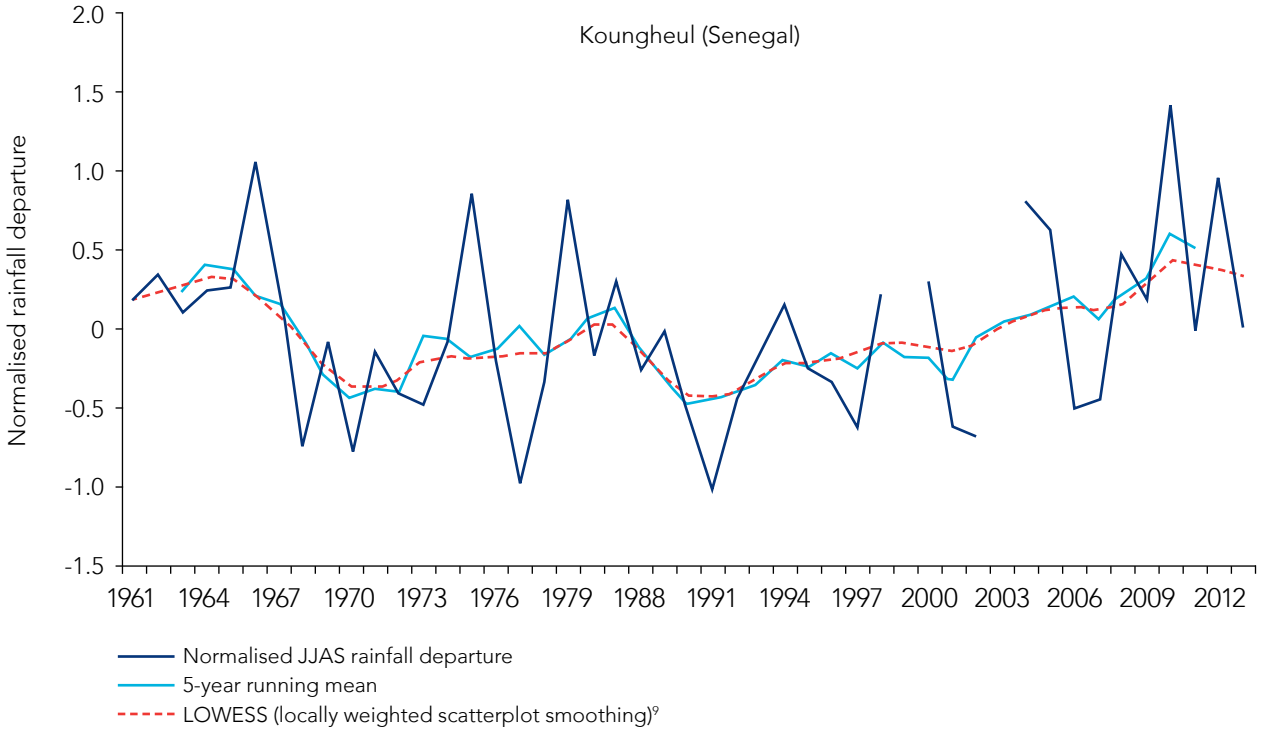
[8] A muslim holy man.

Figure 11: Dry spell frequency in Kaffrine and Koungheul (consecutive days with no rainfall)



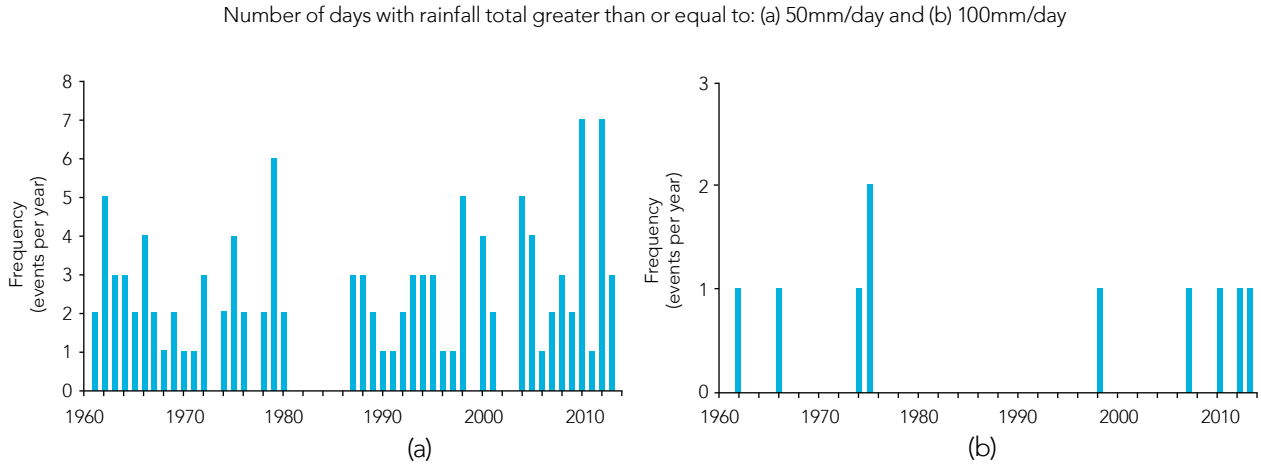
Source: Cornforth and Lélé 2014

Figure 12: Normalised rainfall departure at Koungheul station



Source: Cornforth and Lélé 2014

Figure 13: Extreme wet characteristics recorded at Koungheul station



Date from 1981–1986, 1999 and 2003 seasons are not available

Source: Cornforth and Lélé 2014

[9] LOWESS (Locally Weighted Scatterplot Smoothing), sometimes called LOESS (locally weighted smoothing), is a popular tool used in regression analysis that creates a smooth line through a timeplot or scatter plot to help you to see relationship between variables and foresee trends (source: www.statisticshowto.com/lowess-smoothing/)

Meteorological datasets are available from a range of different sources, including:

- National Agency of Civil Aviation and Meteorology (ANACIM)[10]
- Functioning weather stations at Kaffrine, Koungheul, Malem Hodar, Nganda and Dianke Souf (DGPRE 2014), and
- National Oceanic and Atmospheric Administration's National Center for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR).

Using a global, high resolution, coupled atmosphere-ocean-land surface-sea ice system, the CFSR estimated the state of these coupled domains over 36 years from 1979 to 2014. Daily CFSR data on precipitation, wind, relative humidity and solar for a given location and time period is available from the CFSR website,[11] allowing us to identify, analyse and model past climate extremes.

A range of initiatives are generating predictions of future climate effects, including an integrated famine early warning system established by the Inter-State Committee for Drought Control in the Sahel (CILSS). This is considered to be sub-Saharan Africa's most effective and up-to-date mechanism for preventing and managing recurrent food security crises (Cornforth 2014).

Regional Climate Outlook Forums – particularly Prévisions Saisonnières en Afrique de l'Ouest (Seasonal forecasts for West Africa or PRESAO) jointly organised by the African Centre of Meteorological Applications for Development (ACMAD) and food security stakeholders – convert integrated seasonal climate forecasts into sub-regional food security assessments.

Available downscaled regional climate models include those from CORDEX Africa (Shongwe *et al.* 2015) and scenarios that explore different concentrations of emissions, such as those in the Paris Agreement and the IPCC's 2013 Climate change report (IPCC 2013).

5.2 Modelling the effects of climate change on water resource systems

Models can help us understand and quantify the effects of climate extremes on a region's water systems. By considering a range of possible climatic effects and extremes, we can support probabilistic analyses and explore risks (see dryland-relevant examples in WLI 2013).

For example, a very simple water balance modelling approach using remote sensing can show the effects of rain and pond management on the balance of available water resources in the Ferlo over the course of a year (Soti *et al.* 2010). Observing seasonal effects on ponds in the Ferlo can inform the development of such models (Lacaux *et al.* 2007). Surface runoff modelling can show the effects of different types of vegetation cover during storm events (Séguis and Bader 1997).

A soil and water assessment tool (SWAT) (Box 3) can help us develop analyses that can be more sensitive to a wider array of possible changes in natural resource management (Gassman *et al.* 2007).

Varying the climate scenarios that we feed into a SWAT model – for example, to simulate a drought or a flood —will result in different volumes of water flowing to different parts of the system.

[10] www.anacim.sn
[11] https://rda.ucar.edu/pub/cfsr.html

Box 3: What is SWAT?

The US Department of Agriculture developed the SWAT tool to assess the impact of management techniques on the balance of water, sediments, pesticides and nutrients in watersheds, taking into consideration different soil types and land uses.

SWAT is well known for its robustness and efficient integration of soil, vegetation and management characteristics that can affect water balance calculations. It is routinely used by various government agencies, including US federal agencies and the European Commission. It is occasionally used in sub-Saharan Africa —for example, to study the effects of land management practices in Burkina Faso (Lang, Wellens and Tychon 2011) and climatic extremes and disasters in East Africa (Gies, Agusdinata and Merwade 2014). A version of SWAT called QSWAT can be used with freely accessible QGIS software.

SWAT is a continuous model that works at the watershed level with daily time steps.[12] Its basic components include (Gassman *et al.* 2007):

- Hydrology: establishing the water balance for the basin
- Meteorology: determining the impacts of past climate change on water balance and for future projections
- Soil properties, and
- Land management

We can use SWAT to calculate the volumes of rainwater that:

- Flow off the land surface as runoff
- Infiltrate the soil
- Are taken up by plants and evapotranspiration
- Flow downward through the soil horizons, and/or
- Remain conserved in ponds for other human use.

SWAT can be adjusted to take into account the effects of land management practices. The outputs it generates around water availability under different climatic effects can also be connected to crop production models (see Section 5.3.1) . This can allow us to assess how alterations to land and water management practices can affect crop productivity.

Although Senegal has no official water accounting system, the government began to prepare for a system to monitor water resource extractions and uses in 2016, along with a range of other indicators it needed to monitor the sustainable development goals for water (DGPRE 2016). Among other things, this system will monitor ground and surface water resources across the Ferlo and groundnut basin, assess water extraction for use in different sectors of the economy and calculate the balance between water availability and extractions. Some common assumptions (shown in Box 4) can help to calculate the volumes of water used by humans and livestock.

[12] For an example of how to use the SWAT model to generate outputs on water harvesting impacts, see Ouessar *et al.* (2009).

Box 4: Assumptions about water consumption

In rural West Africa, water consumption does not generally exceed 28 litres per capita per day (l/c/d). This takes into consideration the needs of small stock. For the separate calculation of livestock needs, in Senegal it is normal to assume an average requirement of 25 litres per tropical livestock unit (TLU) per day (20 l/c/d in the wet season and 30 l/c/d in the dry season).

A TLU is an indicator to measure livestock production and corresponds to 250kg of animal weight (Boudet 1975).

Other water requirements for different land uses and crops in arid environments may require production-function water models (see discussion of these in WLI 2013).

Table 5: Norms for human and livestock water consumption (global v Senegal)

Centre type and (population)	Global norms (l/c/d)	Norms in Senegal (l/c/d)
Urban	140	110 (Dakar)
Major towns (10,000+)	–	100
Secondary (5–10,000)	701	60
Rural (under 5,000)	401	50

Source: (DGPRE 2014), p 118

Table 6: Assumptions about TLU (global v Senegal)

Livestock type	Global TLU	Senegal TLU
Cow	0.85	0.73 (Zebu)
Sheep	0.11	0.12
Goat	0.07	0.12

Source: DGPRE (2014) and (Hein, Metzger and Leemans 2009)

5.3 Mapping land management, productivity and adaptations

Land use systems of the Ferlo and groundnut basin include forests, pastures and croplands (FAO 2010a, King 2011, TACC 2013) and the consequences of climatic extremes on these systems will vary. A number of studies have used remote sensing techniques to study processes affecting the land and water systems of the Ferlo and groundnut basin (see: Brandt *et al.* 2014, Cissé *et al.* 2016, Brandt *et al.* 2017).[13] They include effects on cropping areas, rangeland (Diouf *et al.* 2016, Cissé *et al.* 2016, Miehe *et al.* 2010) and forest cover (Nachtergaele and Petri 2013, King 2011).

Wherever possible, remote sensing should be ground-truthed using field data from participatory mapping (described in Section 4), and/or other sources we identify below. This information will help us assess volumes of productivity in different land uses and can provide insights about the factors that affect it.

5.3.1 Crop production

We can use statistics from FAOSTAT and agricultural extension services to assess the volume of crop production in cropping areas (Sonneveld, Keyzer and Ndiaye 2016, Fofana, Tankari and Traore 2017). The main processes governing crop responses to climate are relatively well known and have been modelled in different ways, depending on the crops concerned (Genesio *et al.* 2011, cited in Cornforth 2014), then tracked by early warning systems using climate forecasts and observations, harvest data, market and livelihoods information. Two examples of models recently used to assess the effects of climate on crop production in Senegal are:

- CELSIUS: Cereal and legume crops simulator under changing Sahelian environment (Ricome *et al.* 2017), and
- SARRA-H model: for studying climate effects on yields of millet and sorghum (Ramarohetra and Sultan 2017 in press, Salack *et al.* 2012)

Land management practices and adaptations to climate change are complicated to model. For example, farmers in the driest areas invest in cow fattening as an adaptation to climate effects on crop yields (Ricome *et al.* 2017). This creates manure, which improves yields. Conserving trees and shrubs can also improve crop yields in the study region (Box 5).

Box 5: Effects of agroforestry on crop yields

Studies have found that a number of factors can affect crop yields, including:

- The presence of shrubs, which can increase productivity of crops such as millet and groundnut (Diakhaté *et al.* 2013, Bright *et al.* 2017).
- Intercropping with a legume, which increased millet grain yields up to 55 per cent and combined grain yields by up to 67 per cent (Trail *et al.* 2016).
- An increase in cereal grain yield under several agroforestry species, including B*alanites aegyptiaca, F. albida, P. biglobosa* and *Prosopis africana* (Bayala *et al.* 2014, 2015).
- The presence of trees introduced through assisted natural regeneration techniques, which can triple grain production from 296kg/ha to 767kg/ha (Bakhou and Fall 2011).

[13] Also see: https://tinyurl.com/y8h7kndf

5.3.2 Trees and rangeland production

The regional forest and water inspectorate makes annual inventories of forest resources in Kaffrine (RdS 2015b). Further information on forest resources is available from FAO (2010b). Other field studies are also available. For example, a recent inventory of woody species and their importance for local and migratory populations in the rural community of Lour Escale, Kaffrine (Sarr *et al.* 2013) lists 51 species from 22 taxonomic families and includes information about their uses, such as providing forage for livestock (53 per cent of inventoried species). Field studies like this one can provide a better quality of information than remote sensing. However, where there is a need to cover larger scales of assessment, field inventories and/or participatory resource mapping can be usefully combined with remote sensing techniques.

The responses of trees to climate effects depends on the species, age and other factors. The tree species used in reforestation projects prioritised by DCF include *Acacia senegalensis , Acacia seyal, Anacardium occidental, Bombax costatum , Eucalyptus, Prosopis juliflora and Terminalia mantaly.*[14]

To identify the effects of climate extremes and disasters on vegetation production in rangeland areas, we can carefully combine remote sensing, ground surveys and modelling techniques (e.g. Hein *et al.* 2009). Once again, human adaptation interventions can mediate the effects caused by climate to manage landform and hydrological processes on the ground. In Kaffrine, a previous study has demonstrated that the presence of trees introduced through assisted natural regeneration techniques can triple grain production from 296kg/ha to 767kg/ha.

Various studies have assessed the physical process of carbon sequestration in the study region's rangelands and forests (Diédhiou *et al.* 2017, Loum *et al.* 2014, Sanogo *et al.* 2014). The volume of carbon sequestered includes above- and below-ground vegetation and varies with soil characteristics. One study (Sanogo *et al.* 2014) calculated the above-ground biomass of a forest in Kaolack using the methods described in Brown (1997), which only includes species with a diameter between 5–148 cm at chest height. The species identified in the study included *Balanites aegyptiaca*, *Combretum micranthum*, *Diospyros mespiliformis*, *Mitragyna inermis*, *Guiera senegalensis* and *Combretum glutinosum*, *Acacia seyal*, *Anogeissus leiocarpus*, *Feretia apodanthera*, *Dicrostachys cinera*.

5.3.3 Livestock production

It is possible to estimate animal numbers per household or per unit of water and pasture. One study used an ecological-economic model that connects climate model outputs to rangeland dynamics, grazing and livestock values in the Ferlo under the changing climate (see Box 6). This study is based on the relationship between rainfall and biomass production in the rangeland, which is known as rain use efficiency (RUE) (Le Houerou 1984)

RUE is affected by both rainfall and long-term grazing pressure. This reflects the view that a few years of high grazing pressure have limited impacts on vegetation, whereas sustained high grazing pressure leads to changes in the ecosystem (Le Houérou, Bingham and Skerbek 1988).

In years of scarce rainfall, pastoralists sell the animals they cannot feed. In years of drought, they maintain as many animals as possible on the limited grass resources available, allowing them to restock

[14] Personal communication with Momath Talla Ndao, DCF Coordinator)

Box 6: Calculating the relationship between climate, grazing management and livestock production in the Ferlo (after Hein et al. 2009)

A pasture's annual grass production can be translated into the annual grazing capacity based on the nutritional requirements of each animal type (Hildreth and Riewe 1963). Hein et al. (2009) assume that pastoralists graze animals up to the number than can be supported by the grass production each year. Average livestock densities in the Ferlo have been estimated around 0.15–0.20 TLU per hectare (De Leeuw and Tothill 1990, Miehe 1997).

Hein et al. (2009) estimated the amount of biomass needed per TLU, taking into consideration the livestock mix in the Ferlo (see Thébaud, Grell and Miehe 1995) and the energy requirements per animal (calculated in Bayer and Waters-Bayer 1998). They estimated that each animal needs a minimum of 4.3 kg TLU of food per day. Not all herb biomass is available to the animals, due to decomposition, fire or unpalatability. They also estimated that in the Ferlo, 50 per cent of plant biomass is available for grazing (Penning de Vries and Djitèye 1982, Breman and de Ridder 1991) and that woody plants make up 20 per cent of overall feed supply (Breman and de Ridder 1991). On this basis, pastoralists would need 2,511kg of herb biomass per TLU per year.

quickly after the drought; in years of abundant rainfall, they sell the surplus on local markets (Guerin *et al.* 1993).

Although it is possible to model the number of livestock that different vegetation types can support in theory, calculations of carrying capacity can often be misleading. A more realistic approach to quantifying livestock production is to consider the number of livestock that households are keeping. One study in Kaffrine observed that silvopastoral households may own around ten animals each, including cattle, sheep and small livestock (Ba *et al.* 2006). Another study focusing on the north of Senegal observed that households might own around 44 livestock (Thébaud *et al.* 1995).

In each village where DCF has implemented investments, communities have provided information about the number of people and livestock present. A family portrait study enabled a deeper understanding of the structure of family herds in the village of Maodo Peulh (Tables 7 and 8).

Observed trends affecting livestock numbers and production involve increases in the number of more drought-resistant small ruminants. Connection with livestock markets is another factor affecting livestock raising patterns among the Fulani in Senegal (Adriansen 2006). To develop scenarios about future livestock numbers, survival and productivity rates, we need to make a large number of assumptions. The most advisable starting point for developing such scenarios is a participatory

Table 7: Structure of a family herd in Maodo Peulh village, Koungheul

	Moussa Ka's family			Other members of Moussa Ka's household (his brother, nephew and their families)	Moussa Ka himself		
	Total	Males	Females	Total	Total	Males	Females
Cattle	80	20	60	50	30	5	25
Goats	200	40	160	88	15	5	10
Sheep	140	25	115	82	45	8	37
Donkeys	30	20	10	18	4	1	3
Horses	20	5	15	12	4	1	3

Source: Moussa Ka, agriculturalist

Table 8: Tropical livestock units in a family herd in Maodo Peulh village, Koungheul

	Moussa Ka's family			Other members of Moussa Ka's household (his brother, nephew and their families)	Moussa Ka himself		
	Total	Males	Females	Total	Total	Males	Females
Cattle	68	17	51	42.5	25.5	4.25	21.25
Goats	14	2.8	11.2	6.16	1.05	0.35	0.7
Sheep	15.4	2.75	12.65	9.02	4.95	0.88	4.07
Donkeys	15	10	5	9	2	0.5	1.5
Horses	16	4	12	9.6	3.2	0.8	2.4
TOTAL	128.4	36.55	91.85	76.28	36.7	6.78	29.92

Based on information provided by Moussa Ka, agriculturalist

discussion with local livestock owners to identify the main factors influencing livestock numbers and productivity.

The effects of climate extremes on herd numbers do not only concern the availability of pasture and water. They can also influence the prevalence of diseases affecting livestock productivity and mortality rates, including those associated with mosquitoes hosted in ponds during the rainy seasons. In-migration of animals from surrounding areas can increase the risk of diseases affecting livestock in Kaffrine (Box 7).

Box 7: Modelling the relationship between climate extremes and Rift Valley Fever in the Ferlo

Using a conceptual approach to understanding tele-epidemiology, Lafaye *et al.* (2013) created a predictive, bio-hydrological model of the occurrence of Rift Valley Fever in the Ferlo. This built on a ten-year constructive multidisciplinary approach that began in 2003 (described in Marechal *et al.* 2008, Tourre *et al.* 2009, Vignolles *et al.* 2010)

Lafaye *et al.* used dynamic hazards maps produced after rainfall events and the emergence of two main vectors – *A. vexans* and *C. poicilipes* (Vignolles *et al.* 2009). Although the maps took into account rainfall, mosquito flying range and mosquito aggressiveness, rainfall events were the primary input, since the distribution and intensity of these events determine pond dynamics with regard to the presence of larvae sites and eggs hatching.

The maps showed the zone potentially occupied by mosquitoes (Tourre *et al.* 2009, Vignolles *et al.* 2009). This indicates hazards and vulnerability of livestock parked at night (Tourre *et al.* 2008, Ndione *et al.* 2009).

Source: Lafaye *et al.* (2013)

Effective vaccination can reduce the risks of the spread of some diseases and loss of herds. But without well-organised and constructed vaccination facilities, it can be a challenge for vets to prevent animals from running away and count the animals to establish the price for vaccinations. Sufficient and effective veterinary facilities in place can therefore influence the contribution of livestock raising to the regional economy. Quantitative modelling of the probabilities of disease under different climatic conditions could help to assess the benefits from improved vaccination services as a resilience-building measure for climate extremes and disasters

6. Assessing the value of changes in goods and services

The value of the return on an adaptation investment that affects the availability of public goods and services will depend on:

1. the stocks and flows of units of the goods and services available over a given timeframe (explored in the previous section)
2. the difference made by the investment over a given timeframe (touched upon in the previous section)
3. the value assigned per unit of goods and services

In this section, we explore the third of these, and consider ways in which it is possible to assign economic values to public goods in the regional economy. To do this we explore their value as goods and services creating benefits for human well-being. The methods for valuation vary depending on the nature of goods and services concerned. We present a series of examples from previous studies.

The value assigned to each unit of goods and services can be used to determine the value of the returns on investments in adaptation that affect the flows of these goods and services.

6.1 Assessing the economic uses and value of water resources

Changes in water availability caused by climate extremes and disasters such as drought and floods translate quickly into economic effects. Although we did not consider the value of water resources in the regional profile (see Section 3.1), it is important to consider the economic benefits of local adaptations that manage the effects of climate extremes on water resource availability and use. Adaptations can intervene to alter the distribution of available water resources to ensure they meet basic needs. They can also change the balance between volumes and timings of water and other inputs to economic productivity, including energy, labour or physical inputs.

During extreme events, the flexibility of water allocation for different uses can be important. For example, when bushfires break out during extended dry seasons, if water is on hand for domestic or productive uses, it can also be used to fight fires. This may then help avoid economic damage from loss of property or loss of lives.

The potential uses or transferability of water flows can directly determine their value to society (CCME 2010). The usual direct use values of water include drinking, other domestic purposes and production of goods and services such as crops, trees and livestock (Table 9). In the DFC project, communities have identified a series of benefits from increasing water supplies (see, for example, Box 8).

Tables 9 and 10 show that many of the benefits of increasing water supplies have an economic value. But some of these benefits are more difficult to quantify than others. Those that are challenging to quantify include reduced prevalence of diarrhoeal diseases, reduced pressure on the village's only well and improvements to water management, satisfaction with water point management and food security.

There are also tradeoffs for society that require attention: depending on the source of the new water supply, there may be an opportunity cost in terms of the water reserves that are stored underground or accessible for other uses.

Table 9: Goods and services with direct use value derived from adaptation investments involving water availability in the DCF project

Department	Commune	Village(s)	Adaptation investment	Types of goods and services generated by adaptation investment			
				Drinking water, labour saving, health and safety	Livestock and products	Tree products and environmental benefits	Market gardening
Malème Hodor	Dianké Souf	Mbabanène Bodé et Hamdalaye	Drinking water supply	x			
	Sagna	Thiong	Drinking water supply	x	x	x	
Birkilane	Mbeuleup	Mbeuleup	Extension of drinking water supply network	x	x		
	Ndiognick	Mboukhoumé and Gogdji Keur Serigne Fana	Extension of drinking water supply network	x	x		x
Kaffrine	Nganda	Nganda	Drinking water supply	x	x	x	
	Diamagadio	Wintinckou	Extension of drinking water supply network	x	x		x
	Médinatou Salam II	Coly Peulh, Panthiang 3, et Panthiang Louma	Drinking water supply	x	x		x
Koungheul	Fass Thiéckéne	Médina Panthiang	Drinking water supply	x			
	Maka Yopp	Nguerane, Fass Peulh, Kairawane Ndiayene, et Médina Thiéckène	Drinking water supply	x	x	x	
	Missira Wadène	Banjul Banta	Drinking water supply	x	x		
	Lours Escale	Ndiayène Lour	Drinking water supply	x	x		x

Box 8: The value of a water supply in Banjul Bante village, Missira Wadene, Koungheul

Around 620 inhabitants live in Banjul Bante, with an open, unprotected well as their only water source. Villagers have around 50 cattle, 45 sheep and 48 goats. During the winter, they drink water from ponds, but in the dry season, the ponds dry up and the animals must migrate. Investing in a water supply for the village will reduce health problems (such as diarrhoeal diseases) associated with poor water quality and alleviate the burden of fetching water for women. This will allow children to stay at school and women to engage in other income-generating activities. It will also affect the growth of plants and trees and reduce the need for all animals to migrate, both of which could translate into economic value. Other benefits that are more difficult to quantify are increasing food security and improving water management capacities.

Photo 2: Water supply at Banjul Bante. Diadji Ndiaye

Table 10: Benefits and potential valuation of water supply from DCF investment in Banjul Bante

Benefits	Potential valuation
Volume of water supplied	620 people x volume of consumption x price
Reduced burden of domestic tasks	Time savings
Increased productivity of livestock and off-season produce	Milk Meat Vegetables
Increased income	See above
Water source in case of fire	Reduce risks of destruction of property
Girls going to school	Future value of economic activity by girls

Although domestic water supplies sometimes have a market price, it does not always fully represent their value to society. Water is sometimes available free of charge or at a subsidised rate. But rather than rely on the market price to identify the value of water, we can use its intended use to identify its value to society. This is helpful in cases where water will be used for irrigation or livestock raising or for businesses such as restaurants and hotels, when it is possible to identify how much of the final good or service is enabled by an additional unit of water. But this is not helpful for identifying the cost of domestic water supplies that do not immediately generate an income.

Under drought conditions and other climate extremes, ensuring domestic supplies has to be a higher priority than an additional unit of agricultural production. Failure to secure basic water supplies will lead to higher costs in terms of health, wellbeing and social problems. Water for drinking is often considered a basic right, rather than a commodity. There are a number of reasons why water sometimes cannot be priced, including: absence of property rights; limits on transferability; legal and physical infrastructures; and institutional shortcomings. This is particularly difficult when coupled with questions about return flows, third party impacts, market design, transactions costs and average versus marginal cost pricing (Chambwera *et al.* 2014).

It is important to assign a value to human water use to compare it with the value of other uses, such as for irrigation or livestock. Studies that fail to compare these values have concluded that water for irrigation and intensive livestock production was more valuable than basic drinking water supplies for humans and livestock in vulnerable communities (Silvestri *et al.* 2013). Such skewed findings can lead to bad economic decision making.

To identify the economic value of water resources for drinking and domestic uses, most studies rely either on the cost to society of producing the water (in other words, treatment and infrastructure costs) or on market price and/or the price that users are willing to pay (SROI 2012).

In Kaffrine, some communities have identified the price that they pay for water. For example, household water supplies cost 200 FCFA (US$0.40) per cubic metre in Dianke Souf village, department of Malem Hodar. Domestic water supplies often have a range of prices – for example, they can be free at source or users might pay to pump from boreholes or to transport water by truck. Prices also vary by area, costing more in remote, drier areas than in humid zones. Extreme events such as droughts can exacerbate scarcity, which in turn can further distort prices.

It is important to recognise that public or donor assistance and subsidies for infrastructure, fuel and other operating costs associated with water supply and treatment can affect market prices for water services. We must also understand household cost-saving strategies at different times of the year.

Alternative approaches to drinking water valuation include basing the value on contributions to gross domestic product (GDP) made by the active population (Box 9 and 10).

Ultimately, there is no right or wrong way to value water supplies. It is a social choice that needs to be made, particularly in dry areas.

Box 9: Basing the value of water on GDP

Some studies have sought to re-evaluate the contribution to society and the economy of individuals who receive enough water supplies to maintain health and lead an active life (Hutton 2015). This has led to an argument that the unit value of water for basic needs can be derived from the national per capita GDP. Assuming that, to lead a healthy life, each person needs 40 litres of water a day, 365.25 days a year, they will need 14.61 cubic metres a year to generate the average contribution to national GDP. So the value per cubic metre of domestic water supply would be the total annual per capita GDP ($1,093.40 in 2016)[15] divided by 14.61. This would make the value per cubic metre $74.84.

But controversies associated with valuing a productive human life have received attention in international literature about the value of basic water supplies in drought-prone environments (Luedeling *et al.* 2015). Using GDP as a total sum of national productivity also attracts criticism because it overlooks many dimensions of value and fails to account for externalities – such as the cost of pollution – from the economic activities it values.

Source: Hutton 2015

[15] https://tradingeconomics.com/senegal/gdp-per-capita

Box 10: The value of an extension to the water supply network in Kaffrine

The cost to extend the water supply network to 1805 inhabitants in 2 villages of Mbabanene and Bode and 3 neighbouring hamlets is FCFA 4,600,000 ($9,200). The price of a cubic metre of water is FCFA 200 ($0.40).

According to the norms for the rural areas of Senegal (DGPRE 2014 p118), each inhabitant consumes around 40 litres of water per day, which is 14.61m^3/year, at a value of FCFA 2,922 ($5.84). During the first year of operation, if we use the market value of the water, the extension will create a value of FCFA 5,274, 210 ($10,584.42) – which already exceeds the expenditure.

This calculation does not take into account the value of benefits achieved by avoiding illnesses, watering livestock close to the village during the dry seasons and alleviating the burdens placed on women and children. If we apply Hutton's method (see Box 9) to capture these aspects of the value of the water supply, the value estimate will be far higher.

The number of years of duration of these benefits depends on the maintenance of the network, the water source, and the balance between extraction and recharge.

6.2 Assessing forest production and fuel value

In this section, we explore how to assign values to public goods and services from forest production. We focus on values to human wellbeing in the regional economy. These include fuel value, and also a range of other direct use values. To apply these values, we must also understand access and use rights and conventions, as well as access to markets for the tree products.

The direct use values of tree production may include wood and non-wood products, such as fruits, fibres, leaves, roots, etc (Tables 11 & 12). The value of these products varies according to their uses – whether for fodder, human consumption, medicinal or cosmetic uses, or others. These values are often affected by markets and the availability of processing systems. Taxes on forest products collected in 2014 in the region of Kaffrine amounted to FCFA 16,900,400 (more than $30,000) (RdS 2015b).

Trees full potential value is not apparent until they mature. Seedlings may require intensive human labour to care for and water them when they are small, to protect them while they grow and to raise awareness of the need to conserve the forest. An economic valuation of trees and tree products requires us to consider the life cycle of the trees in question. The time period of interest is an important factor when designing studies on returns on forestry system investments.

Forests often require local management, which costs time and effort. In Mbeuleup, the community forest institution gains income from collection and sales of honey (Box 11). Elsewhere in the region of Kaffrine, local institutions concerned with forestry have adopted practices that enable them to combine reforestation activities using indigenous tree species, with cultivation of other trees and tree products that will generate revenue to support their operations (Box 11 & 12). However, cultivation of seedlings and commercial tree products can often require significant inputs of water (Box 13). This demand for water can increase vulnerability to drought, and is not always fully taken into consideration in economic assessments.

Table 11: Range of forest products and value sources in and around Kaffrine

Value type	Use	Examples from our studies and other literature	Value
Timber products	Fuel	The two most prevalent Sahelian species in the north of the Ferlo at Niassanté and Diaglé boreholes – *Balanites aegyptiaca* and *Boscia senegalensis* – are also the most commonly used species for firewood (Dendoncker, Ngom and Vincke 2015).	-
		Households near the classified forest of Dankou, Nganda Commune consumed 2,695m^3 of firewood per year (they got 15 per cent or 404m^3 from the forest and bought the rest). They used the market price to value the portion of firewood sourced from the forest (Gueye 2005).	Local markets
	Wood	Folding chairs and doors made from Eucalyptus wood in Mbeuleup attract buyers from Touba town in the Diourbel region and can sell for 3,000 FCFA (DCF Family portrait investigation, 2017).	Local markets
Non-timber products	Gums	*Mbepp* gum or resin (*Sterculia setigera*) has a range of medicinal and other uses[16] (Ba et al. 2006, Sarr et al. 2013)	Local markets
	Fruits	Edible fruits such as *jujube* (fruit of *Ziziphus Mauritania*) and baobab fruit powder with a range of uses (Ba et al. 2006, Diop et al. 2006, Sambou et al. 2016)	Local markets
		A nursery enables the family to make additional income from selling young plants and mangoes (DFC 2017)	Local markets
	Medicines	A family keeps a stock of four 50kg sacks of *neb neb* (pods of *Acacia albida*) to sell for medicinal uses. Each sack is worth 3,000 FCFA or a 100kg sack is worth 5,000 FCFA. They can also grind the pods into powder to sell. They also sell *Jatropha curcas* known as *tabanani* in local markets (DCF Family portrait investigation, 2017).	Local markets
	Forage	Providing forage for livestock is an important aspect of the value of forests in Kaffrine and the surrounding region: 53 per cent of species inventoried in one study could be used for forage (Sarr et al. (2013).	Value of livestock
	Honey	Apiculture is a communal activity that provides honey and generates revenues for public services and loans in Mbeuleup (DCF Family portrait investigation, 2017).	Local markets
	Other wildlife		?
Other benefits	Carbon	Carbon sequestration is an aspect of the value of forest production to global society that local community members did not list in their theories of change for investment in forests. But a recent study used an international market price of 13 euros per tonne to value carbon stored in forests in the neighbouring regions of Kaolack and Fatick. Due to financial crises, this price has fluctuated between 8–30 euros (Sanogo et al. 2014).	International markets

[16] See: http://plants.jstor.org/stable/10.5555/al.ap.upwta.5_293

Table 12: Value of various products collected from forests in Kaffrine (2014)

Product type	Product	Units	Unit price (FCFA)	Number per year	Total value (FCFA/year)	Total value (US$/year)
Fruits	Baobab (*Adansonia digitata*)	kg	15	477,825	7,167,375	14,335
	Ziziphus (*Zizyphus mauritiana*)	kg	15	3,690	55,350	111
	Balanites	kg	15	20	300	1
	Dimb (*Cordylia pinnata*)	kg	15	300	4,500	9
Gums	Mbepp (*Sterculia setigera*)	kg	100	480	48,000	96
	Arabic (*Acacia senegal*)	kg	100	100	10,000	20
Leaves and fibres	Mbepp (*Sterculia setigera*)	kg	15	400	6,000	12
	Baobab (*Adansonia digitata*)	kg	15	1,200	18,000	36
	Ronier palm (*Borassus aethiopum*) fibres	kg	15	1,000	15,000	30
	Ronier palm (*Borassus aethiopum*) leaves	kg	15	200	3,000	6
	Various leaves	kg	15	530	7,950	16
	Various barks	kg	30	6,410	192,300	385
Roots	Various	kg	30	5,615	168,450	337
Incense	Sedge gowé (*Cyperus articulates*)	kg	15	300	4,500	9
Carved wood	Quranic tablets	1	50	80	4,000	8
Raffia	Raffia bed	1	600	25	15,000	30
	Raffia sofa	1	600	12	7,200	14
	Raffia chair	1	200	30	6,000	12
	Raffia table	1	200	9	1,800	4
	Raffia cabinet	1	200	1	200	0
	Stems of raffia	1	75	400	30,000	60
Bamboo	Stems of bamboo	1	75	301	22,575	45
Fuelwood	For heating	-	500	2524	1,262,000	2,524
Pillars	Pillars	-	500	15	7,500	15
TOTAL					9,057,000	18,114

Source: (IREF 2014)

Note: See https://sites.google.com/site/ethnosenegal/liste-des-plantes for local names.

Box 11: Forestry in Mbeuleup

A family portrait study conducted for DCF in Mbeuleup revealed that Eucalyptus plantations attract buyers from Touba town in the Diourbel region. Folding chairs and doors made of Eucalyptus wood can sell for 3,000 FCFA.

The family keeps a stock of four 50kg sacks of *neb neb* (*Acacia albida* pods) to sell for medicinal use. Each 50kg sack is worth 3,000 FCFA; a 100kg sack is worth 5,000 FCFA. The family can also grind the pods to sell as powder. *Jatropha curcas* – known as *tabanani* – can be sold at Ngouye in Kaffrine or at Gossas in Fatick region.

The family can also make additional income from selling young plants and mangoes from their nursery. In 2016, the household made 414,000 FCFA (US$822) from forest products, which was enough to support the family. Apiculture is a communal activity that provides honey and generates revenues for public services and loans.

Box 12: Restoring classified forest in Kaffrine

An investment supported through DCF is intended to enable the association of Femmes Forestieres to reforest 12.5 hectares of the classified forest of Kaffrine. This will create a firebreak and is anticipated to provide wood for fuel and construction as well as other non-wood forest products and forage for livestock. Sales of the non-timber forest products are expected to generate income. A nursery will also sell forest plants and fruits such as mangoes directly to raise money for the association to carry out awareness-raising activities for conservation of the forest.

These activities and the improved availability of goods and services from the forest will benefit 6000 people living in the surrounding villages of Sikilo, Diogo, Pété, Médina Niasse, Nianghène Bambara, Médina Mounawara, Niaghène Wolof, Touba Keur Cheikh.

Photo 3: Femmes Forestières, Kaffrine. Caroline King-Okumu

Box 13: The economics of agroforestry in Linguere

In a six-hectare plot, a farmer protects seedlings of *Balanites aegyptiaca, Tamarindus indica, Faidherbia albida, Acacia radiana, Borassus aethiopum, Lawsonia inermis* and *Moringa oleifera*. In parallel, he has planted 100 *Acacia senegal* and a lot of fruit trees (*Mangifera indica, Citrus maxima, Citrus limon, Cerasus vulgaris, Citrus sinensis, Citrus reticulata* and *Ziziphus mauritiana* of the *gola* variety. The field is surrounded by a live hedge of *Acacia mellifera*. In another part of the plot, he practices crop rotations of millet and maize and fallow. He also grows groundnuts and black-eyed peas.

Of the plot's set-up costs, the irrigation system is the most expensive (Table 13). Of the maintenance costs, energy is the highest, followed by water (Table 14).

Table 13: Costs (in US$) and inputs needed for establishing an agroforestry plot

Input	Specific input	Unit	Quantity	Cost per unit (US$)	Total costs (US$)
Labour	Transporting plants and trees		1	8	8
Plant material	Seedlings	ha	1	16	16
Fertilisers and biocides	Biocides	ha	1	12	12
Other	Water	ha	1	100	100
Other	Irrigation system		1	3,800	3,800
Total cost of establishing the technology					3,936

Table 14: Annual costs (in US$) and inputs needed for plot maintenance/ recurrent activities

Input	Specific input	Unit	Quantity	Costs per unit	Total costs (US$)
Labour	Labour	ha	1	93	93
Equipment	Fuel and equipment	ha	1	208	208
Plant material	Seedlings	ha	1	140	140
Fertilisers and biocides	Biocides	ha	1	32	32
	Compost / manure	ha	1	85	85
Other	Water	ha	1	153	153
Total costs for maintaining the technology					711

Source: (Ndiaye 2017)

In addition to their direct use values, trees are often valued for their contributions to supporting and regulating the ecosystem. Trees can affect soil qualities associated with crop production and soil-water interactions, enabling groundwater infiltration and storage and creating a microclimate in which other species can thrive. Some of the effects of trees on soil qualities associated with crop production have been studied in the area around Kaffrine (see Section 5.3.1). This additional value might be reflected in the economic value of the crop. The presence of trees also often leads to other values associated with habitat creation, aesthetics and so on. These are more difficult to price and value.

For the global community, the ability of trees and forests to sequester and store carbon is increasingly considered to have an economic value as a means to mitigate climate change. Interestingly, communities in Kaffrine and surrounding regions also believe that the presence of trees has a direct effect on local rainfall. However, it is not possible to place a value on this perceived effect.

Previous studies have demonstrated how some of the uses of trees and forest systems that we have identified can be valued and combined in an economic assessment (see e.g. Box 14). These studies demonstrate that it is necessary to select a feasible range of value types for inclusion in the assessment.

Box 14: Combined value of different forest products

A study by Sanogo et al. (2014) in Kaolack and Fatick, regions neighbouring Kaffrine, developed a valuation of the combination of goods and services provided by communal forest areas (Table 15). It focused on the values of firewood, fruits, charcoal, forage and others.

The study estimated that households living near the communal forest areas use 10.4m^3 of firewood, 3.2m^3 of other wood and 313kg of fruits, leaves, hay and forage each year. It calculated that, in 2010, the forests contributed 46,000 FCFA to each household's income (13 per cent of household income) in Ndock Sare village and 279,000 FCFA per household (44 per cent of household income) in Keur Nième.

The wild fruit trees included *Balanites aegyptiaca*, *Ziziphus mauritiana* and *Acacia nilotica*. Community members value and sell some of these fruit products on the markets, but they use the larger proportion (around 75 per cent) as dietary supplements for subsistence consumption.

Table 15: Value of selected forest products using local and international market prices

	Quantities of production (kg per hectare per year)		Average price per kg (FCFA)		Production costs per kg (FCFA)	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
Carbon sequestered	1,282	790	-	-	-	-
Exploitable wood	4,133	3,427	15	15	-	-
Exploitable fruits	1,200	113	200	200	25	25
Charcoal	-	2945	-	80	-	18
Honey	-	28	-	2,700	-	500

Source: (Sanogo et al. 2014)

We have tentatively explored options for valuation of forests where DCF has implemented adaptation investments (Box 15). This preliminary exploration has been made by an external consultant. It inevitably requires further discussion and adjustment by the local actors and stakeholders.

Box 15: Rapid assessment of benefit streams from trees in reforestation projects (prepared by Vanja Westerberg, consultant)

A rapid assessment was undertaken to estimate the value of timber and non-timber forest products (NTFPs) that can be collected and harvested over a 15-year period in 4 reforestation interventions financed by DCF in the region of Kaffrine. The reforestation projects are implemented over four areas covering some 82 hectares in total. For most trees species, yields of timber, fuel and NTFPs yields are not of significant magnitude until at least 5 years after trees are planted and revenues may often take longer to accrue. Therefore, while reforestation investment costs are immediate, provisioning ecosystem service benefits take a longer time to materialize.

The present value benefit from the anticipated forest income flow is estimated to be in the order of 54.5 million francs CFA, using a modest cost of capital of 2% and a 15-year time horizon. After subtracting project investment costs, the Net Present Value benefit is in excess of 7 million francs CFA (Table 16). This value however, is an underestimate of the real net-benefit because there was insufficient time to gather data from local stakeholders on the full range of products that can be sustainably harvested from the different tree species involved in the reforestation interventions. Additionally, other benefits, such as habitat creation, soil and water conservation were not accounted for. These services are of considerable relevance to the regional economy and resilience to climate extremes.

Finally, forest landscape restoration is recognized as an important contributor to climate change mitigation because of its carbon storage potential. The global benefits from reforestation activities in Kaffrine were valued using the 'social cost of carbon', which serves as an estimate for the avoided global damages from mitigated emissions. Accounting for the additional 108'110 tons CO_2-eq GHG emissions that are sequestered as a result of the restoration interventions leads to significantly higher social net-benefits. If appropriate institutional arrangements were in place – e.g. through a voluntary carbon market project – local stakeholders would be able to capture part of this value.

Table 16: Rapid estimates of Net Present Value (r=2%) from 4 reforestation interventions in Kaffrine in FCFA

	Creation of village woods, Dimal	Restoration of the Mbeuleup community forest	Restoration of the banks of the tributary of the Saloum river at Keur Mboucki	Restoration of the classified forest of Kaffrine	Total
Present Value of marketable forest products	17'079'690	14'560'720	5'587'180	6'417'660	54'641'375
PV project implementation costs	-8'762'265	-6'917'780	-21'232'425	-10'099'030	-47'951'730
Net Present Value	7'247'720	6'223'055	-16'652'985	-4'313'103	7'629'875
NPV including carbon sequestration	865'331'880	563'512'760	311'290'410	269'565'495	2'009'700'550

(Source: Vanja Westerberg)

6.3 Assessing agricultural production and value

To assess the value of agricultural production, we need to consider not only the value of the final product, but also the fixed and variable input costs (Fofana *et al.* 2017). In this section, we examine how to assign values to public goods and services from various types of agricultural production to human wellbeing in the regional economy.

6.3.1 Rangeland production

Our initial profile of the region (Section 3.1) did not take the value of rangeland production into consideration. Having worked out the number of animals (as described in Section 5), we then needed to identify the livestock products, input costs, production volumes and prices.

Meat is the main source of income for pastoralists in the Ferlo (Hein *et al.* 2009), followed by milk production (Sutter 1987, Guerin *et al.* 1993). The DCF family portrait investigation in Koungheul confirmed that the sale of livestock for meat was most important to the household (Table 17). The family considered milk production to be low and of no economic value, in line with the observation that the role of milk production and agriculture has decreased over the last decades in the Ferlo, while the focus on livestock herding for meat production has intensified (Adriansen 2006).

Beyond the Ferlo, a growing number of studies have been devoted to assessing the total economic value of rangeland production (Davies 2007, Silvestri *et al.* 2013, McGahey *et al.* 2014, King-Okumu, Wasonga and Yimer 2015, Shine and Dunford 2016, Wasonga *et al.* 2016). These include the consideration of a wide range of products from livestock under extensive and intensive production.

The livestock prices identified by DCF in 2017 (Table 17) were broadly similar to the average value of 24,750 FCFA TLU (Hein *et al.* 2009), but noticeably higher than sales prices identified in the national economic accounts for agriculture for 2011 (Fofana *et al.* 2017). In the Ferlo, livestock prices tend to decrease during droughts, as farmers want to sell livestock that they cannot feed – for example, the DCF family portrait investigation found that a household in Maodo Peulh may sell around five cows and ten sheep during the dry season while their food-stocks are depleted. Immediately after a drought, livestock prices can increase substantially as farmers restock (Turner and Williams 2002). In light of this, Hein *et al.* assumed in their calculations that prices would drop to 43 per cent during drought years and increase to 146 per cent in the two years subsequent to a drought.

Regarding the costs of livestock herding in northern Senegal, Hein *et al.* (2009) assumed that all costs are variable costs, related to capital and labour inputs required to maintain the herd. The capital costs per livestock unit amount to the

Table 17: Sale price of livestock in Maodo Peulh, by season

	Price range (FCFA)	
	Rainy season	Dry season
Cattle	250,000–300,000	150,000–155,000
Sheep	50,000–80,000	25,000–30,000
Goats	(35,000–25,000	20,000–15,000

Source: DCF family portrait investigation (2017)

local, real interest rate multiplied by the price of a livestock unit. They calculated this as:

$$0.16 \times 24{,}750 = 3{,}960 \text{ FCFA TLU}$$

Labour costs associated with livestock raising include the labour of children, who play an important role in herd management in Kaffrine when they are not in school. A household might also hire additional labour to take the herds to pasture. In Maodo Peulh, the DCF family portrait investigation revealed that households pay around 150,000 FCFA for a labourer to take their herds North to Djolof from July until January. This is 50 per cent more than previous estimated labour costs (Hein *et al.* 2009).

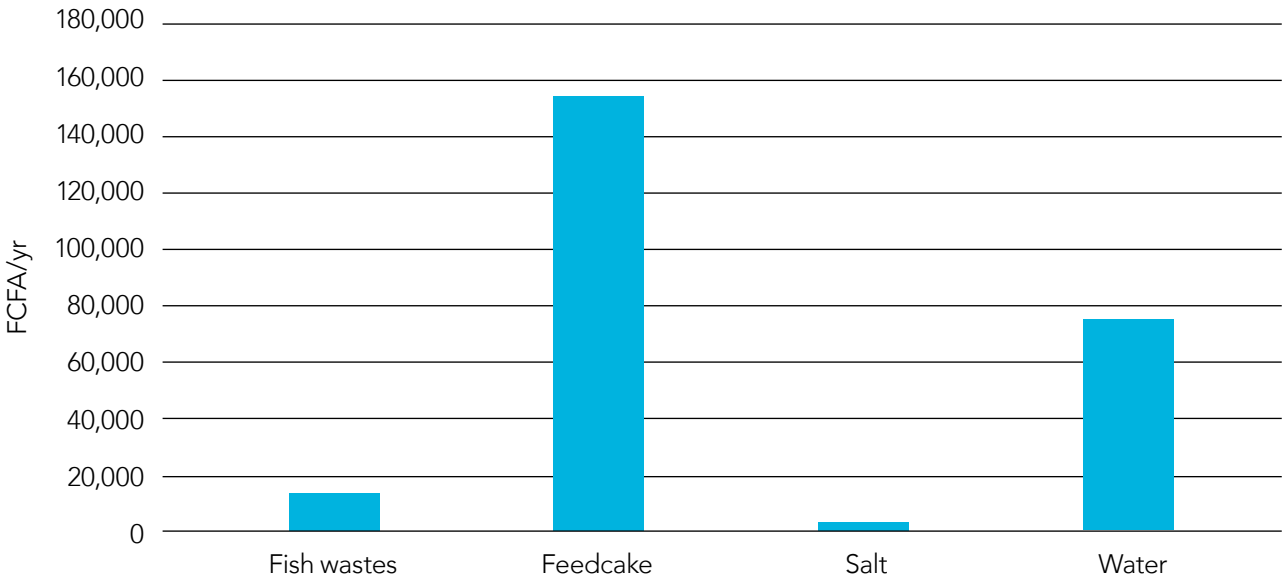
Other important variable costs of livestock production in Kaffrine indicated in the DCF investigation but not considered in the previous study (Hein *et al.* 2009) include feed supplements made from fish waste, feed cake, salt and water, which adds up to an annual variable cost of 418,950 FCFA (see Figure 14).

Livestock need vaccinations several times a year. In Maodo Peulh village, a vet comes at his own expense to give vaccinations each January. But for the second and third vaccinations, the household must pay the vets' transportation costs (10,000 FCFA) and also the cost of the vaccination (around 300 FCFA a head for cattle, horses and donkeys and 50 FCFA a head for goats and sheep. If both the second and third vaccinations are given at the same time, the costs per head are still doubled.

To obtain the total production costs per livestock unit, we must multiply the costs for vaccinations by the number of livestock units, and then add it to the fixed cost and the veterinary fees

We can calculate the value of livestock to the regional economy as its sale value, minus the fixed and variable production costs. The valuation can focus on the value of the whole stock of livestock assets, rather than only the annual offtake of livestock.

Figure 14: Household expenditure on livestock feed supplements and water during the dry season in Maodo Peulh



Source: DFC family portrait investigation (2017)

Box 16: Accounting for livestock production in Kaffrine (2011)

Economic accounts for livestock have been developed using available market information and data from the 2011 poverty monitoring survey ESPS by Senegal's National Statistics and Demography Agency (ANSD), a nationwide survey that covered the 2010/2011 agricultural season in the country's 14 administrative regions. Livestock production data presented in the ESPS includes, among other things:

- Animal head count by category
- Subsistence value
- Value of donations and gifts
- Money generated from sale of livestock products
- Total cost of veterinary products and services
- Cost of other livestock operating expenses, and
- Main sources of funding for livestock inputs.

Livestock production includes: self-consumption (including donations and gifts); sales; and holding gains or gross fixed capital formation – for example, due to animal fattening.

Expenditure on livestock includes: veterinary products and services and other livestock inputs.

Table 18: Value of livestock production in Kaffrine (2011)

Livestock type	Average price nationally (FCFA)	Head count value (million FCFA)	Production value (million FCFA)	Veterinary expenses ratio (hundred FCFA)	Other expenses ratio (hundred FCFA)
Cattle	99,406	2,600	20.6	2.1	6.8
Goats	12,987	43.8	6.1	0.7	3.6
Sheep	20,944	110	9.3	9	27.3
Poultry	1,578	5.9	0.8	2	4.4
Pigs	13,113	0	0	0	0
Horses	123,960	103	0	0	0
Donkeys	12,517	6.7	62.9	266	800.8
Others	2,000	0.2	7.8	1,610.1	595.9
All		529.6	107.5		

Source: (Fofana et al. 2017 p23-24)

It is acknowledged that the value of livestock production indicated in these accounts is likely to be an underestimate as they assume that the livestock head count remains stable over the course of the year, which is recognised not to be the case.

6.3.2 Market gardening production

For market gardening, we need to consider surface area, number of products by hectare, price of produce and the cost of inputs, including the value of water, chemicals and labour.

In the DCF project, adaptation investments in market gardening have been proposed to improve women's incomes. In some locations —such as Mbeuleup in Birkelane – communities have proposed to undertake surveys of the income generated. This will identify the benefits to households. However, in order to identify economic returns for society as a whole, we would also need to consider any potential effects on the broader environment and society. Sometimes the inputs to production can create tradeoffs for society – particularly in the case of competing demands for water.

6.3.3 Other crop production

For groundnuts and other crops, market prices are available at statistical offices and in economic accounts for agriculture (Fofana *et al.* 2017, Sultan *et al.* 2010). As we mentioned in Section 4, these aspects of value are routinely considered in regional economic profiling and planning. But we must remember that pastoralist Fulani households also grow crops such as peanuts, millet and black-eyed peas for human consumption and animal feed (Manoli *et al.* 2014). Therefore, the market price (which they do not pay) is not necessarily relevant to them. As a result, the value may be under-estimated.

Once again, in the valuation, there is a need to consider the crop production budget – including the costs of inputs as well as the value of output. There is also a need not only to consider these from the financial perspective of individual farmers, but to take a wider view of possible effects on the environment and society as a whole.

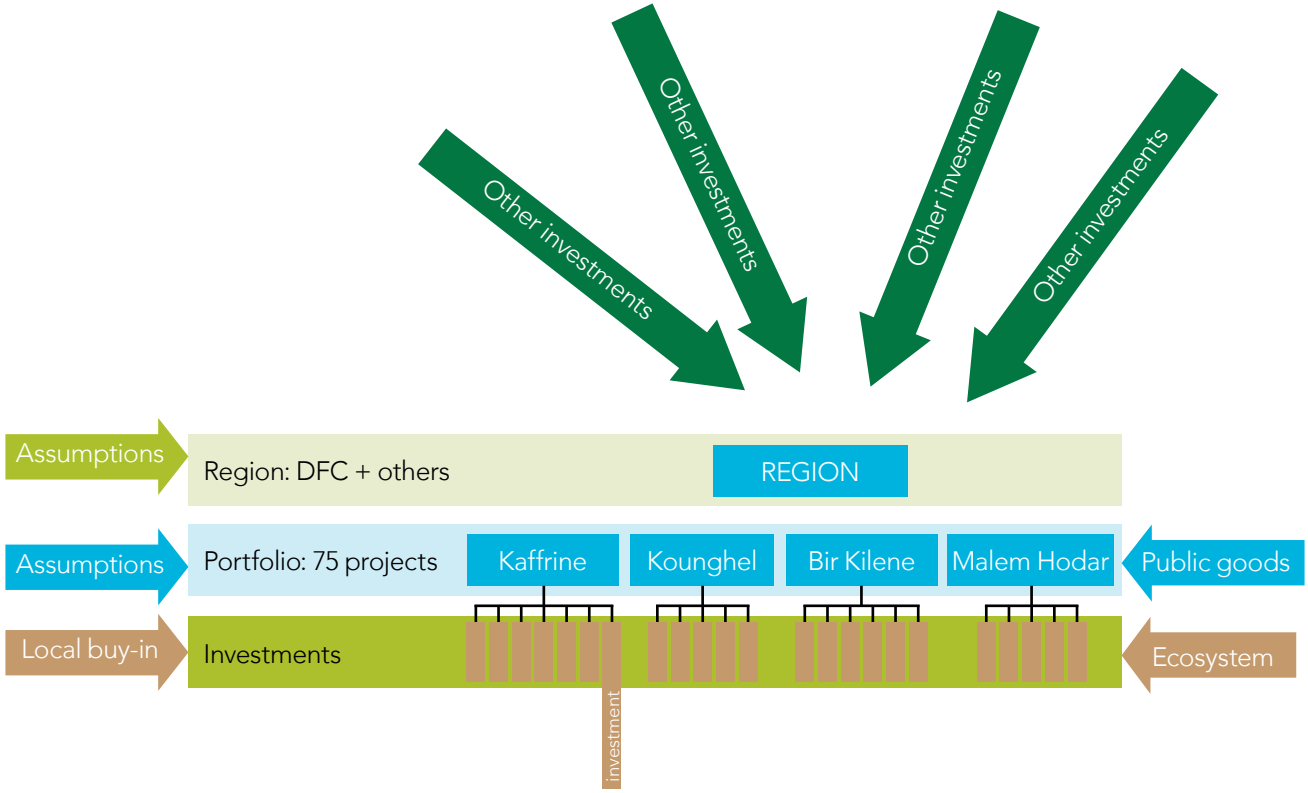
7. Predicting future economic returns

We can project a basic calculation of future returns on investment – either in a single adaptation or regional development scenario – over a given planning time horizon, such as 2015–2030. This projected data would provide an *ex-ante* assessment of returns on adaptation investments likely to be of interest to regional, national and international decision makers. National and international decision makers might also use the assessment to compare returns on possible adaptation investments in Kaffrine and the wider territory of the Ferlo with other adaptation investments elsewhere.

Previous assessments of returns on adaptation investments in Senegal have used IMF data on economic growth to address the 2030 horizon and beyond (IBRD 2013a, IBRD 2013b). We propose to develop a simplified projection of benefits from adaptations in Kaffrine that focus on the effects of the adaptations and use qualitative assumptions about the regional economy only, rather than immediately connecting our economic scenarios to any particular macroeconomic model. By generating data and assumptions on the regional economy, we will provide information that decision makers could later choose to combine with a macroeconomic modelling approach, should they wish to do so.

This will require identifying timeframes that are relevant to decision making across each of the selected three scales of interest: regional, individual investments and portfolio level (Figure 15) and projection of potential benefits. Relevant planning timeframes range up to 2030. But one and five-year timeframes are also important thresholds within which local stakeholders need benefits.

Figure 15: Three levels of interest for economic assessment in DCF



Assessing future returns will involve discounting a portion of the future value. Although this is common practice in economic assessment, there are often debates about selecting discount rates. They can be around 10 to 12 per cent in the public sector in developing countries (Markandya and Halsnaes 2001), but some environmental studies have preferred to select much lower discount rates, at one to three per cent (Jepsen 2003). This would be fairer to future generations. An assessment of returns on investments in Kaffrine should use the discount rates that will be acceptable to economic decision-makers in Senegal. The effects that the choice of discount rate will have on the final results of the calculation can be examined and discussed using a sensitivity analysis.

Due to high levels of uncertainty surrounding the time, extent and magnitude of extreme events and disasters, a probabilistic presentation of anticipated returns would be desirable. The quantitative modelling techniques we describe in Section 5 should help enable this and demonstrate sensitivity to climatic extremes. But at each scale, additional assumptions about non-biophysical effects will need to be built into the scenarios. After identifying these qualitatively, planners should discuss them with stakeholders through a participatory approach before investing in any attempts to quantify them.

Discussing and clarifying assumptions at investment, portfolio and region scales and across different timeframes can offer a more complete picture of the value of returns on investments.

7.1 Predicting the value of returns at individual investment level

At the level of individual investments, the assessment will reflect considerations that have shaped the project selection and designs. Capturing stakeholders' economic calculations can be helpful in explaining to national and international decision makers how they perceive the expected benefits. This process could complement ongoing work by DCF with local stakeholders to monitor and evaluate the success of their investments, with relevant timeframes ranging from short to longer term.

We anticipate complementarities between benefits to the economy and society and private benefits to vulnerable community members. Calculating these benefits may reflect the costs and benefits of adaptations in a format similar to an expanded version of the relevant household, farm or enterprise budgets. We would need to identify a range of input costs and output values at this scale. Inputs may include purchased or non-purchased inputs, while outputs may include economically valuable goods and services as well as externalities that we should weigh against the value of these goods and services. This will help us fully understand the final benefit for the economy and society as a whole, beyond the benefits to immediate project beneficiaries.

Among these inputs and externalities, a particularly drought-sensitive and critical one often concerns water resource requirements and availability. Overlooking this can be expensive and place vulnerable populations at unnecessarily increased risk during climate extremes and disasters.

We can use simple Excel spreadsheets (e.g. similar to those presented in Noleppa 2013) to calculate the net present value of benefits from adaptation investments. Although the design and content of these will vary, according to the nature of investments and anticipated returns (see Section 6), it is possible to summarise the benefits and compare them quantitatively (Table 19). These quantified comparisons may or may not reflect the qualitative comparisons and decisions made during the project selection process.

Table 19: Calculation of returns on investment

	Costs	Benefits year 1	Benefits year 5	Benefits year 10	Benefits year 15
Investment 1	ff	ff	ff	ff	fff
Investment 2	ff	ff	ff	ff	fff
Investment 3	ff	ff	ff	ff	fff
Investment 4	ff	ff	ff	ff	fff
Investment 5	ff	ff	ff	ff	fff
Investment 6	ff	ff	ff	ff	fff
TOTAL					

7.2 Predicting the value of returns at a programme/ portfolio level

The DCF project will need to assess the value that it generates at the portfolio level, as well as through individual projects. This value will include the aggregation of all benefits achieved through the individual projects. This value is central to the DCF concept (Figure 16). But there also needs to be a strategic discussion among DCF stakeholders to consider whether any other aspects of value are generated through the decentralised approach that should be taken into account at portfolio level. They should ask, for example:

- Have the project prioritisation processes generated strategic insights and contributed to regional planning debates?
- Have any of these been documented?
- Will they generate insights of interest to national level thinking concerning adaptation planning?

A donor will need to weigh the portfolio-level assessment benefit against costs of both individual investments and establishing the financing mechanism. These include preparing, setting up and running the programme as well as support for effective monitoring, evaluation and mainstreaming to ensure sustainability.

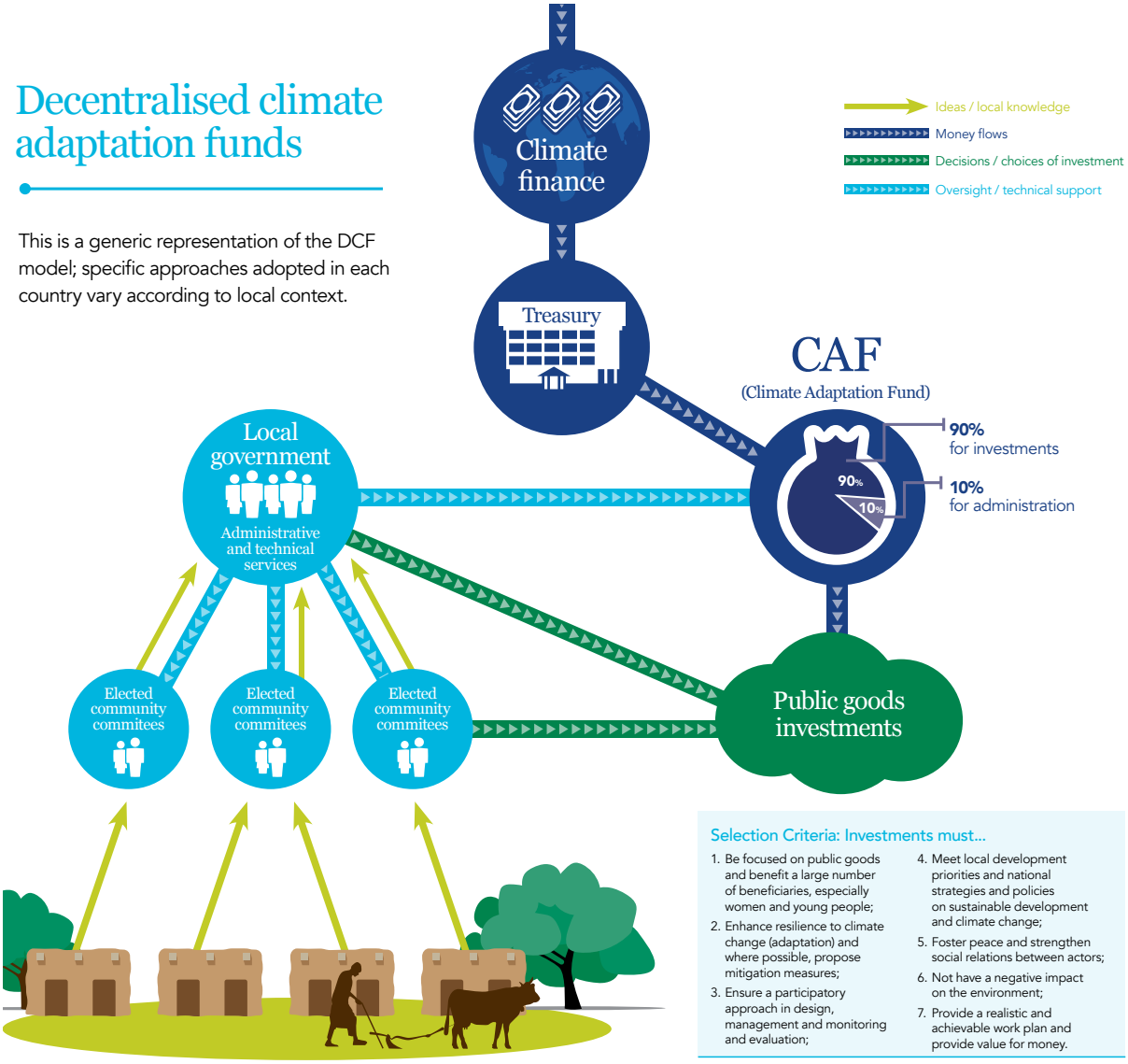
Project stakeholders may also want to discuss the extent to which they can imagine or model a comparative assessment, comparing with and without DCF scenarios, focusing retrospectively on the project lifetime or prospectively over a future timeframe or timeframes. This might involve, for example, a five-year timeframe for a second phase of investments and/or longer timeframes following the implementation of investments.

We might expect the following multiplier effects to ensure that the decentralised adaptation scenario would be more favourable than the scenario where all adaptation planning takes place through a centralised system:

- Higher success rate for preventing losses when disasters strike
- Higher rate of economic activity due to lower risk and higher returns; and
- Increased synergies among social, environmental and economic co-benefits.

Relevant questions to consider in this assessment may concern the extent to which locally prioritised investments are likely to be sustained or replicated both by local stakeholders and other initiatives or financing mechanisms. The assessment could identify, explain and build assumptions about these effects into the presentation of alternative scenarios.

Figure 16: The devolved climate finance concept



With the decentralised financing mode, we may expect local buy-in to mean a greater percentage of investments are successfully implemented. But it will probably be difficult to identify a comparable control that uses a non-decentralised approach to implement a similar portfolio of interventions and where there is complete transparency around failure.

7.3 Predicting the value of returns at regional level

In Section 3.3 we identified some gaps in regional-level planning scenarios and economic profiling. In particular, there are gaps around the assessment of water resource availability and rates of extraction, especially during climate extremes and disasters. Adaptation investments and other future investments are likely both to affect and be affected by the future availability and uses of water. Developing improved regional-level scenarios could help planners at both regional and national levels to prepare better for climate extremes and disasters. Exploring these planning scenarios with regional stakeholders will also help the project team think through and present the assessment of the effects of the individual investments.

DCF project documents and theories of change already show complementarities between investments prioritised by communities and other ongoing investments at regional level. This level of assessment will give a more complete picture of why adaptations are necessary, how they contribute to building overall resilience and their value to the economy and society.

In the regional scale assessment, we are not bound to present value that is neatly attributable to the DCF project alone. For example, while there may have been significant investment in livestock raising across the region, without an effective vaccination programme, its value may be reduced. If the local community decides to invest in a vaccination programme, the value of livestock raising in the regional economy will increase and everyone will benefit. But this value is a combined product of investments made at different stages by a range of actors. Attributing the value generated to any one investor, as required for a project or portfolio-level assessment, is complicated and artificial.

We might expect a full regional economic assessment to demonstrate synergies between returns on decentralised investments in public goods and private investments by community members. It might also suggest avoided public expenditures on emergency response and social assistance. Such an assessment would illustrate and argue the economic case for a decentralised approach to climate adaptation finance.

In the regional scenarios, there is room to consider other assumptions. For example, if DCF has successfully invested in a village water supply or solar-powered pumping system, would this be replicated across the region? If so, over what timeframe? Stakeholders could consider qualitatively what nature of assumptions should be factored into the elaboration of future scenarios at regional level.

8. Beyond the economic assessment of returns on investments

We have demonstrated that methods and tools exist to enable an economic assessment of returns on investments in locally prioritised adaptation investments in Kaffrine and possibly other similar contexts. But it is very important to acknowledge that any such assessment will remain partial and be unlikely to quantify and assess the value of all benefits from adaptation investments. So we must ensure that space is reserved within the assessment to identify and discuss benefits that escape quantification and economic valuation (see examples in Box 17). These may include: critical contributions to resilience building through individual and institutional capacities; establishing norms and good practices; and encouraging learning in various forms.

Discussing and effectively documenting these benefits that are not included in the economic assessment can achieve two important results. First, it will ensure that decision makers do not consider the assessment to be exhaustive. This will avoid unnecessary fear that an (unlikely) low result from the assessment could cause decision makers to argue that returns on investments in adaptation in the region of Kaffrine could be too low to merit serious consideration.

Second, in cases where we can identify benefits from investments but cannot yet fully take them into consideration in an economic assessment of returns on investment, documenting them effectively may encourage further research. Discussing shortcomings or limitations in any assessment design can therefore provide an impetus through which the missing economic benefits will eventually be captured.

Box 17: Benefits beyond economic valuation from improved water supply at Missira Wadene

In addition to quantifiable effects on resource availability and uses, the DCF stakeholders have identified the following social benefits from investment in water supply system:

- Reinforced management capacities
- Reduced over-extraction from wells
- Good management of waterpoints
- Level of household satisfaction with management of waterpoints
- Reduced conflicts
- Improved hygiene conditions
- Reduced frequency of diarrhoeal diseases
- Girls staying in school
- Improved food security

These benefits can be more difficult to definitively quantify and value than the physical effects on natural resource conditions.

9. Conclusion

Although there are many challenges associated with assessing returns on adaptation investments, we have demonstrated a workable approach to quantify some of their immediate direct returns, even in the face of climate extremes and disasters in the drylands. These generic measures could be applied to assess returns on both centralised and decentralised adaptations and to capture possible synergies between them.

At the time of writing, this methodology for assessing returns on adaptation investments is in a pilot *ex-ante* assessment phase in the BRACED DCF programme. In 2018, DCF may consider a second assessment phase to begin monitoring the benefits of adaptation investments, observing tangible effects on the ground as they emerge. This would enable us to start preparing some *ex-post* assessment of returns on investment and could focus on benefits achieved over a defined period – for example, one to five years. It could also help regional planners project returns over a longer period – to 2030 and beyond.

Quantitative economic assessment of returns will remain partial even after adaptation investments have been completed. This is because some aspects of assessments will always be qualitative. But we anticipate that even a partial assessment would probably reveal that returns on locally prioritized adaptation investments will outweigh those of centralised investments alone. We could also foresee increasing complementarities and mutually reinforcing feedbacks between strengthened local institutions, the decentralised investment system and the broader portfolio of public and donor-funded investments for sustainable development.

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Appendix

List of DCF projects implemented in the Kaffrine region (2016–17)

Département: Malème Hodor			
Commune/ Arrondissement	Village(s)	Proponent	Title
Darou Minam II	Diaga K. Serigne	Commune de Darou Minam 2	Construction d'un magasin céréalier (Diaga K. Serigne)
	Madina Mbaye	Commune de Darou Minam 2	Construction d'un magasin céréalier (Madina Mbaye)
Sagna	Touba Ngeuyene	Commune de Sagna	Construction d'un magasin céréalier (Touba Ngeuyene)
	Tobene	Commune de Sagna	Construction d'un magasin céréalier (Tobene)
	Thiong	Commune de Sagna	Adduction d'eau potable dans le village de Thiong
Malème Hodor	Taiba Badianene	Commune de Malem Hodar	Mur de clôture d'école Taiba Badianene / Amélioration de l'environnement scolaire de l'école Taiba Badianene
	Malème Hodor	Commune de Malem Hodar	Agriculture Biologique et de Reboisement / Projet intégré de Maraichage et Arboriculture biologiques
	Delby, Mbacouma, Léwé, Tawa Keur, El Hadji	ASBL Malem Auder	Reboisement de Naatal école et potagers, maraichage ecologique (Delby, Mbacouma, Léwé, Tawa Keur, El Hadji)
Ndioum Gainth	Khour Loumbi	Commune de Ndioum Gainth	Construction d'un parc à vaccination (Khour Loumbi)
	Thioyi Ndioum	Commune de Ndioum Gainth	Construction d'un magasin céréalier (Thioyi Ndioum)
	Darou Niang	Commune de Ndioum Gainth	Construction d'un magasin céréalier (Darou Niang)
Ndiobéne Sama Lamo	Ndiobène S. Lamo	Commune de Ndiobène Sama Lamo	Parc de vaccination (Ndiobène S. Lamo)
	Paffa	Commune de Ndiobène Sama Lamo	Construction d'un magasin céréalier (Paffa)
	Sainthe Abass	Commune Ndiobéne Sama Lamo	Moulin à mil multifonctionnel / Mise en place d'une unité de transformation céréalière dans le village de Sainthie Abass
	Ndiobéne Sama Lamo	Commune Ndiobéne Sama Lamo	Moulin à mil multifonctionnel / Mise en place d'une unité de transformation céréalière dans le village de Ndiobène samba Lamo
	Pafa	Commune Ndiobéne Sama Lamo	Moulin à mil multifonctionnel / Mise en place d'une unité de transformation céréalière dans le village de Pafa

Département: Malème Hodor			
Commune/ Arrondissement	Village(s)	Proponent	Title
Dianké Souf	Navarene	Commune de Dianké Souf	Construction d'un magasin céréalier (Navarene)
	Touba Mbayene	Commune de Dianké Souf	Construction d'un magasin céréalier (Touba Mbayene)
	Mbabanène Bodé et Hamdalaye	Commune Dianké Souf	Adduction d'eau potable
	Bouleyda	Commune Dianké Souf	Mise en place d'une unité de transformation céréalière avec abris / Mise en place d'un moulin à mil avec abris dans le village Bouleyda
Khelcom	Touba Khelcom	Commune de Khelcom	Construction d'un parc de vaccination avec un abreuvoir
	Ndindi	Commune de Khelcom	Construction d'un parc de vaccination avec un abreuvoir
Département (trans-commune)	Ndioum Gainth, Ndiobène Samba Lama, Dianké, Darou Minam II	Conseil départemental de Malème Hodor	Promotion de la Régénération naturelle assistée (Ndioum Gainth, Ndiobène Samba Lama, Dianké, Darou Minam II)

Département: Birkilane			
Commune/ Arrondissement	Village(s)	Proponent	Title
Touba Mbella	Touba Mbella	Commune de Touba Mbella	Construction de latrine au CEM de Touba Mbella
	Bossolèle	Commune Touba Mbella	Redynamisation d'une Unité de Transformation de Produits Locaux
Segré Gatta	Keur Sette Awa	Comme de Segré Gatta	Construction d'un magasin céréalier
Mabo	Koumpeul Wolof	Commune de Mabo	Construction d'un magasin céréalier
	Sine Madamel	Commune de Mabo	Construction d'un magasin céréalier
Keur Mboucky	Keur Mboucky	Commune de Keur Mboucky	Reboisement et restauration des berges
	Keur Mboucky	Commune de Keur Mboucky	Construction d'un foyer des femmes
Diamal	Diamal, Gama, Ngordjilene Mouride, et Korky Bambara	Commune de Diamal	Création de bois villageois
	Logol	Commune Diamal	Construction de mur de clôture d'un bloc administratif et d'aménagement de jardin d'école et d'aire de jeux / Amélioration de l'environnement scolaire de l'école de Lougol

Département: Birkilane			
Commune/ Arrondissement	Village(s)	Proponent	Title
Mbeuleup	Mbeuleup	Commune de Mbeuleup	Création et restauration des réserves forestières
	Ndiaguène	Commune Mbeuleup	Construction de mur de clôture d'école / Amélioration de l'environnement scolaire de l'école de l'école de Ndiaguene
	Mbeuleup	Commune Mbeuleup	Extension de réseau d'adductions d'eau potable
Ndiognick	Mboukhoumé et Keur Goumbo	Commune Ndiognick	Adductions d'eau potable / Projet Extension du réseau d'eau dans le village de Mboukhoumé et Gogdji Keur Serigne Fana
	Thianta	Commune Ndiognick	Construction de mur de clôture d'école / Amélioration de l'environnement scolaire de l'école de l'école de Thianta
Birkelane	Birkelane	Commune Birkelane	Birkelane ville propre et verte / Projet d'amélioration de l'hygiène, de l'assainissement et de l'environnement de la commune de Birkelane
	Birkelane	Commune de Birkelane	Projet de jardin potager intégrer au verger des femmes

Département: Kaffrine			
Commune/ Arrondissement	Village(s)	Proponent	Title
Kathiotte	Kathiotte	Commune de Kathiotte	Construction d'un parc à vaccination (village de Kathiotte)
	Kathiotte	Commune de Kathiotte	Acquisition d'une unité de transformation de produits agro industriels / Projet de construction et d'équipement d'une unité de transformation de produits céréaliers
Nganda	Nganda	Commune de Nganda	Construction d'un parc à vaccination (village de Nganda)
	Nganda	Commune de Nganda	Equipement foyer de la femme / Projet de renforcement des moyens de production et de transformation des produits
	Nganda	Commune de Nganda	Réhabilitation foyer des jeunes / Adduction d'eau potable
Diockoul Mbelbouck	Darou Mandakh	Commune de Diockoul Mbelbouck (pt. 1)	Construction de parc à vaccination (villages de Darou Mandakh)
	Missirah Tobene	Commune de Diockoul Mbelbouck (pt. 2)	Construction de parc à vaccination (villages de et Missirah Tobene)
	Mara	Commune de Diockoul Mbelbouck	Construction d'un magasin de stockage (village de Mara)

Département: Kaffrine			
Commune/ Arrondissement	Village(s)	Proponent	Title
Medinatou Salam II	Kelimane Gouye	Commune de Médinatou Salam II	Construction d'un magasin céréalier (village de Kelimane Gouye)
	Coly Peulh, Panthiang 3, et Panthiang Louma	Commune de Médinatou Salam II	Adduction d'eau potable
Kahi	Kaffrine	Assc des femmes forestières de Kaffrine	Restauration de la forêt classée de Kaffrine
	Kahi et Haffé Tidiane	Commune de Kahi	Construction de mur de clôture d'écoles / Amélioration de l'environnement scolaire de l'école de Kahi et Haffé Tidiane
Boulel	Boulel	Commune de Boulel	Projet d'amélioration de l'hygiène, de l'assainissement et de l'environnement de la commune de Boulel Ville Propre
Diamagadio	Wintinckou	Commune de Diamagadio	Extension du réseau d'adduction d'eau potable vers le village de Wintinckou
Kaffrine	Kaffrine	Commune de Kaffrine	Construction de mur de clôture d'école / Amélioration de l'environnement scolaire de l'école de l'école VIII de Pèye
Gniby	Gniby	Commune de Gniby	Amélioration de la résilience des exploitations familiales / Projet d'amélioration de l'aviculture villageoise et de l'élevage ovin
Département (trans-commune)	Kaffrine	Conseil départemental	Recyclage et de valorisation des déchets plastiques et composite / Amélioration de l'hygiène et de l'assainissement dans la commune de kaffrine
	Kheindé	Conseil départemental	Electrification solaire dans 1 village de la commune
	Touba Keur Cheikh	Conseil départemental	Electrification solaire d'une poste de santé de la commune
	Kaffrine	Conseil départemental	Construction d'un bloc de 3 salles de Classe CEM 1 et 2 commune Kaffrine / Amélioration de l'environnement scolaire de l'école CEM Babacar Cobar NDAO de Kaffrine

Département: Koungheul			
Commune/ Arrondissement	Village(s)	Proponent	Title
Ida Mouride	Ida Mouride	Commune Ida Mouride	Création, de délimitation et de bornage des parcours de bétail
		Commune Ida Mouride	Construction banque céréalière
Fass Thiéckéne	Médina Panthiang	Commune Fass Thiéckéne	Adduction d'eau village Médina Panthiang
Maka Yopp	Nguerane, Fass Peulh, Kairawane Ndiayene, et Médina Thiéckène	Commune Maka Yopp	Approvisionnement en Eau potable
Saly Escale	Keur Bara	Commune Saly Escale	Banque Céréalière à Keur Bara
	Koumbidia Socé	Commune de Saly Escale	Périmètre maraîcher
Ribot Escale	Boky Dior	Commune Ribot Escale	Construction d'un parc à vaccination
	Maodo Peulh	Commune Ribot Escale	Construction d'un parc à vaccination
	Commune de Ribot	Commune Ribot Escale	Construction d'un parcours de bétail
Koungheul	Koungheul	Commune de Koungheul	Transformation des produits locaux
	Koungheul	Commune de Koungheul	Gestion des déchets
Gaint Pathé	Ndiolkhos	Commune Gaint Pathé	Maraichage et construction d'un magasin céréalier
Missira Wadène	Banjul Banta	Commune Missira Wadène	Adduction d'eau potable
Lours Escale	Nioro Kéba	Commune de Lour Escale	Fonçage de puits et équipement solaire
	Ndiayène Lour	Commune de Lour Escale	Adduction d'eau potable
Département (trans-commune)	Gaint Pathé	Conseil départemental	Construction d'un mur de clôture au collège de Gaint Pathé / Amélioration de l'environnement scolaire du collège de Gainth Pathé

Organisations

Near East Foundation (NEF)

For over 30 years, NEF has developed sustainable, community-based approaches to manage forests, fisheries, rangelands, and agricultural lands in Mali. Operating out of a principal office in Sévaré, the NEF team of approximately 40 development professionals works to implement programs that are consistently community-based, participatory, and multi-sectoral.

NEF also coordinates a national-level working group on climate adaptation and assists Mali's government in climate policy – including participating in Mali's official delegation to international climate negotiations. NEF's headquarters in Syracuse, United States, provides overall project management and governance oversight to the consortium.

Innovation, Environnement, Développement (IED Afrique)

IED Afrique is an independent not-for-profit organisation based in Senegal. The organisation builds on fifteen years of experience in francophone West Africa and works on issues related to sustainable development and citizenship in Africa by prioritising methodological and participatory innovations.

International Institute for Environment and Development (IIED)

IIED is a policy and action research organisation. We promote sustainable development to improve livelihoods and protect the environments on which these livelihoods are built. We specialise in linking local priorities to global challenges. IIED is based in London and works in Africa, Asia, Latin America, the Middle East and the Pacific, with some of the world's most vulnerable people. We work with them to strengthen their voice in the decision-making arenas that affect them – from village councils to international conventions.

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Decentralising Climate Funds (DCF)

Decentralising Climate Funds (DCF) is an action-research and advocacy project supporting communities in Senegal and Mali to become more resilient to climate change through access to locally-controlled adaptation funds. It is part of the UK government-funded BRACED programme and is implemented by the Near East Foundation (NEF) with Innovation, Environnement et Développement en Afrique (IED Afrique) and the International Institute for Environment and Development (IIED).

To find out more:

We will be sharing lessons and experiences from this project through a variety of different publications which will be made available online:

www.neareast.org/braced

Further reading:

Accessing resilience: reconciling community knowledge with government planning – Policy Brief
www.neareast.org/download/materials_center/DCF_Policy_Brief_En.pdf

Decentralisation of climate adaptation funds in Mali – Fact Sheet
www.neareast.org/download/materials_center/Decentralisation-Mali.pdf

Decentralisation of climate adaptation funds in Senegal – Fact Sheet
www.neareast.org/download/materials_center/Decentralisation-Senegal.pdf

Climate adaptation funds – Backgrounder
http://pubs.iied.org/17341IIED/

Managing the boom and bust: supporting climate resilient livelihoods in the Sahel – Issue Paper
http://pubs.iied.org/11503IIED/

Tracking Adaptation and Measuring Development: a step-by-step guide – Toolkit)
http://pubs.iied.org/10100IIED/

Rethinking cost/benefit assessments of decentralised investments in resilience building
http://braced-rx.org/stories/#story-6

Adaptation to climate change: economic value and return on investments
http://www.neareast.org/download/materials_center/DCF_Literature_Review_En.pdf

For all DCF project publications visit: www.neareast.org/resources/#braced

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