Business case development for the Western Area Peninsular Water Fund, Sierra Leone

October 2020

Gwyneth Letley and Jane Turpie
Anchor Environmental Consultants (Pty) Ltd.

PREFACE AND ACKNOWLEDGEMENTS

This report was commissioned by Catholic Relief Services (CRS) in partnership with The Nature Conservancy (TNC) through the *Replenish Africa Initiative* funding by the Coca Cola Foundation to develop a business case for the investment in proposed nature-based solutions for the Western Area Peninsular Water Fund, as well as to engage with key stakeholders to get their support for the prioritisation of investments.

The study was carried out by Anchor Environmental Consultants, South Africa with input from TNC and Villanova University, USA on the hydrological and hydraulic modelling of the BAU and Conservation scenarios, and input from Zutari, South Africa on conventional engineering costs.

We are grateful to Simon Okoth, Caroline Raes, Jean-Philippe Debus, Azeez Oseni, Paul Emes, and Alpha Amadu Bah from CRS, Colin Apse, Fred Kihara, and Tracy Baker from TNC, Virginia Smith, Angela Cotugno and Wesley Shugart-Schmidt from Villanova University, and the National Water Resources Management Agency (NWRMA) for useful discussions, technical inputs, data, and feedback on an earlier draft.

TABLE OF CONTENTS

ACCRONYMS AND ABBREVIATIONS

1D	1 Dimensional
2D	2 Dimensional
ANR	Assisted Natural Regeneration
BAU	Business as usual
CBA	Cost-benefit analysis
CCBS	Climate, Community and Biodiversity Alliance Standard
CDM	Clean Development Mechanism
CIESIN	Center for International Earth Science Information Network
CRS	Catholic Relief Services
CTFA	Conservation Trust Fund Act
DFID	Department for International Development
FAO	The Food and Agriculture Organization of the United Nations
GEF	Global Environment Facility
GFCC	Global Forest Cover Change
GRNP	Gola Rainforest National Park
Ha	Hectares
ISAT	International Security Advisory Team
LULC	Land use land cover
METT	Management Effective Tracking Tool
$MtCO_2e$	Million metric tonnes of CO_2 equivalent
NDVI	Normalized Difference Vegetation Index
NPAA	National Protected Area Authority
NPV	Net Present Value
NWRMA	National Water Resources Management Agency
PES	Payments for Ecosystem Services
PUD	Photo-user-days
REDD+	Reducing emissions from deforestation and degradation
ROI	Return on Investment
SCC	Social cost of carbon
SSL	Statistics Sierra Leone
SWAT	Soil and Water Assessment Tool
TNC	The Nature Conservancy
UNDP	The United Nations Development Programme
UNEP	The United Nations Environment Programme
UNESCO	The United Nations Educational, Scientific and Cultural Organization
UNWTO	United Nations World Tourism Organisation
VCS	Verified Carbon Standard
WAP	Western Area Peninsula
WAPNP	Western Area Peninsula National Park
WAPFR	Western Area Peninsula Forest Reserve
WTTC	The World Travel & Tourism Council
WWF	The World Wide Fund for Nature

EXECUTIVE SUMMARY

Introduction

The city of Freetown, Sierra Leone has expanded rapidly over the past few decades. This has led to rapid loss of forested area in the Western Area Peninsula (WAP), and increasingly within its 18 337 ha Western Area Peninsula National Park (WAPNP). The remaining forests are important for supplying a range of ecosystem services to Freetown and beyond. Critically, about 90% of Freetown's freshwater supply comes from the watersheds that originate from the WAPNP. As a result of fuelwood harvesting and forest clearing for agriculture and settlements, water is becoming contaminated with sediments and pollutants, the risks of water shortages, flooding and landslides are increased, and the important wildlife populations in the area, notably the endangered Chimpanzee, are becoming increasingly threatened, diminishing the potential tourism benefits that could be derived from the area in future.

The aim of this study was to determine the economic value of the difference in priority ecosystem services flows between a Business-as-Usual (BAU) scenario and a Conservation scenario which is focused on the WAPNP and facilitated by a Western Area Peninsula Water Fund (WAPWF), and analyse these benefits in relation to the costs of implementation to determine the net present value (NPV), return on investment (ROI), and cost-effectiveness of the Conservation scenario.

The terms of reference for the study were to undertake the following steps with the input of parallel hydrologic modelling studies:

1. Evaluate the potential feasibility of a range of potential conservation interventions;
2. Compile a Conservation scenario;
3. Estimate the cost of the Conservation scenario interventions;
4. Calculate the cost effectiveness and ROI of the WAPWF in terms of the water security objectives (expressed in physical terms); and
5. Calculate the NPV of the WAPWF taking other benefits into account.

In addition, as a first step, the study undertook a brief review of the forest degradation and potential trajectory of change in order to estimate the state of the area at 2050 under a BAU scenario.

Potential forest degradation under a BAU scenario

We analysed the change in canopy cover across the Western Area Peninsula National Park using the Global Forest Cover Change (GFCC) Tree Cover dataset (30 m resolution). From 2000 to 2015, 10 587 hectares of forest experienced some thinning or loss of canopy cover, equating to an overall loss of 2103 ha of forest. This is an average loss of 140 ha per year. Recorded canopy cover ranged up to 83% in 2000 but by 2015 there were no areas with more than 64% canopy cover.

The most serious driver of forest loss within the WAPNP is urban area expansion. By 2011, 3200 ha had been encroached by human settlements that housed some 100 000 people. There are also extensive marijuana plantations and some smaller agricultural activities taking place.

The urban demand for charcoal has grown rapidly in the last couple of decades, and some of that demand is being met from within the WAPNP. Logging and charcoal production activities appear to be prevalent in the south-western section of the park. Large quantities or wood are also being harvested daily for fish smoking in the Tombo village area.

From 2001 to 2020, the remaining area under natural vegetation on the WAP declined from 72% to 63%. Urban areas of the WAP are predicted to increase by 197% between 2015 and 2050, with significant encroachment into the WAPNP. By 2050 it is estimated that there will be a loss of 5 115 hectares of forest from within the WAPNP, just less than one third of current forest cover (Figure I).

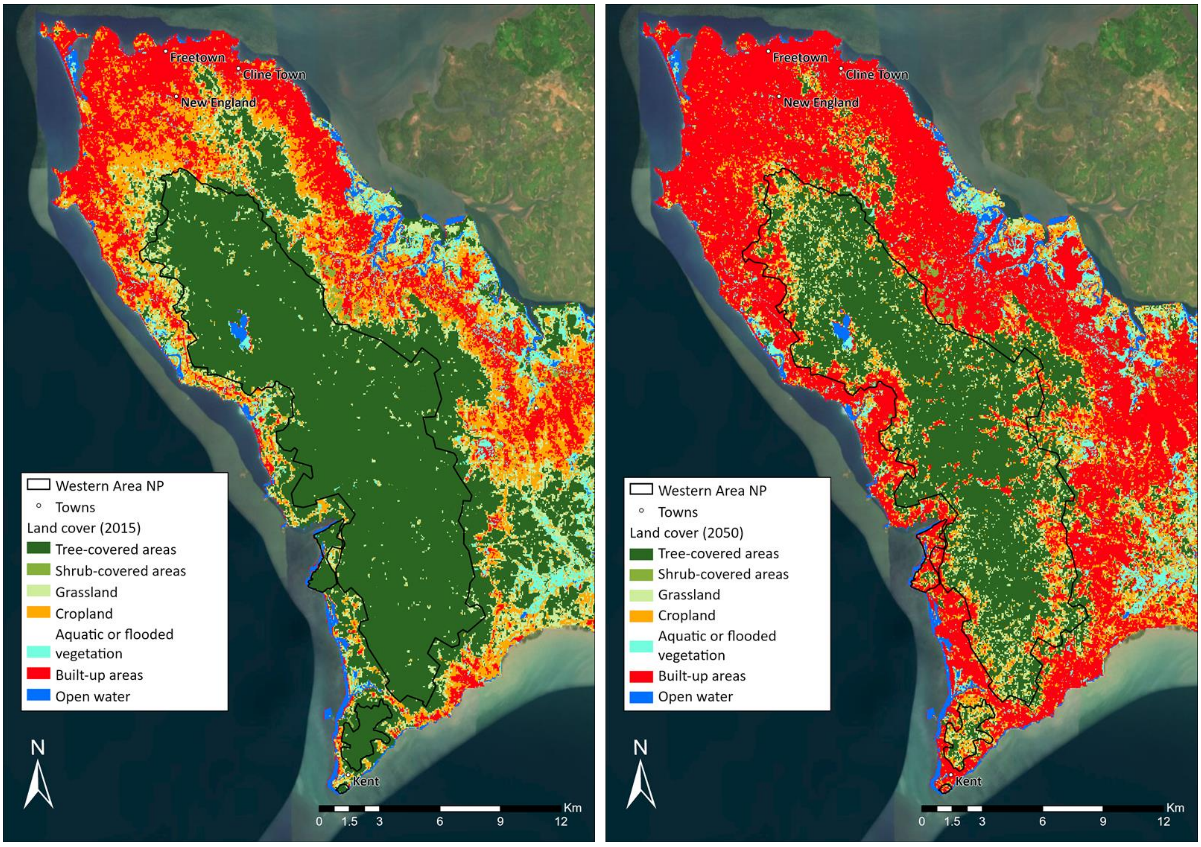

Figure I. **Past (2015) and projected (2050) land cover for the Western Area Peninsula. The 2050 land cover was used for the BAU scenario.**

Identification of conservation interventions

The focus of the WF is on improving water security for the Freetown municipal area relative to the BAU using nature-based interventions. The main options to be considered would be aimed at halting and reversing the deforestation that has taken place in the WAPNP as well as to preserve or restore forest areas in the riparian zones of the urbanised areas below the park, with a view to retaining or improving the regulation of flows and retention of sediments, in particular.

A literature review was undertaken of potential interventions to reduce deforestation and/or restore forest cover and their costs. This benefited from some recent meta-analyses that have been carried out on the drivers and interventions used to address deforestation. There is no one single intervention seen as the panacea for stemming forest loss. Rather, given the fact that many interventions are specialised and effective only under specific conditions, an *intelligent combination* of policy options is preferred for effecting change. Previous studies have found that one needs a mix of interventions that are directly aimed at forest conservation and supporting or enabling interventions. Active interventions would include strict controls (e.g. effective protected areas), mechanisms to incentivise conservation actions (e.g. payments for ecosystem services), and mechanisms to reduce the demand for damaging activities (e.g. agricultural reforms, alternative livelihoods), as well as restoration activities that are feasible in areas treated under the first two. Supporting interventions include mechanisms to gain political, government and community support (e.g. political advocacy, education, capacity and awareness raising), to enable more effective law enforcement (e.g. to address systemic issues such as capacity, corruption, judicial and legal structures and facilities), to improve cooperative landscape management (e.g. through agreements and bylaws), and of course to ensure the sustainable financing of all of the above. The following sets of interventions were considered as the elements of a Conservation scenario.

Effective protection of the WAPNP

Protected areas are the most important and effective strategy for conservation. However, park effectiveness in developing countries is jeopardized by severe underfunding, with the result that illegal activities often continue unabated. Park effectiveness is correlated most strongly with the density of guards, and is also dependent on their capacity and equipment. The number of guards required to effectively protect a park is a function of the size of the park, its location and accessibility, as well as the type of wildlife in the park. Estimates of required funding for effective park management vary from US$192 per km^2 to US$2180 per km^2 per year (in 2019 prices). The African Parks model has a management cost of about US$1000 per km^2 per year.

Sierra Leone has amongst the worst performing protected area systems in the world based on forest loss over the period 2000–2012. Thus, strengthening their protected area systems is a high priority nationally as well as in the WAP. Currently, the WAPNP has about 150-300 guards, but their effectiveness is compromised by low salaries (~US$125/month), high staff turnover and reported corruption. Creating an effective protected area will therefore require increasing the number of staff and their working conditions, undertaking training and capacity building, and monitoring performance using the Management Effectiveness Tracking Tool. In order for the park to achieve its conservation objectives, the revamp of the park will also require the elimination of existing illegal activities, including production of charcoal, marijuana and other crop production. Given the challenges and large capacity and financing requirements, a public-private partnership may be a good option, particularly if a high-value, low impact tourism strategy is undertaken. This has been successfully implemented for many flagship parks in other African countries.

Forest restoration within the WAPNP

Forest restoration can be achieved through active restoration, involving planting or seeding, through assisted natural regeneration (ANR), which involves interventions such as weeding, fire prevention, attracting seed dispersal, and fencing to control livestock grazing and other disturbances, or through passive regeneration which occurs naturally through protection against disturbances. ANR is more feasible at scale and is more cost-effective. However, some active restoration will be necessary, such as in severely degraded areas around the edges of the WAPNP or in areas where illegal agriculture has cleared the forest. Passive regeneration covers the greatest area and involves, through protection, the natural restoration of canopy density. We estimated the maximum potential extent of active restoration, assisted natural regeneration and passive regeneration interventions in the WAPNP based on spatial data on the extent of degradation. The most suitable areas for active and ANR activities based on factors such as accessibility and slope would need to be identified through field visits.

Agroforestry buffer zones between urban edge and park boundary
Protection of the WAPNP forest habitats and ecosystem services would be enhanced by maintaining forested or semi-forested areas around the park. Given that there is little forest remaining around the park, the most viable option for a buffer zone is to establish agroforestry in order to increase tree cover. This will help to serve as a deterrent to further encroachment of human settlement and the exploitation of WAPNP resources. Encouraging tree planting within existing cultivation areas requires both clear land ownership, a payment of ecosystem services scheme to encourage the planting and retention of trees, and a competitive bidding process for participation. A total of 1152 ha of land around the WAPNP was identified as potential agroforestry buffer zones. As long as the PES covers the opportunity costs of the intervention (the costs of the trees and their impacts of original crop production), then it is likely that households would also enjoy additional productive benefits from the trees, e.g. fruits or firewood.

Advocacy, communication and social mobilization
Without buy-in and the political will to change current systems from those at the top levels of government, conservation effectiveness is limited. There will be a need to further investigate potential models of advocacy that can harmonise interests and priorities, especially among water, land and environmental conservation. Awareness raising and social mobilization are also critical for protection of the WAP forests. This needs to include raising awareness of specific policies, laws and regulations that relate to the protection and management of natural areas and how these policies relate to improving livelihoods and water security.

Law enforcement
Enforcement of the law is a vital component of any regulatory system. Sierra Leone faces major challenges in terms of environmental compliance and enforcement. Improved inter-ministerial cooperation and improved cooperation from local authorities is needed. Furthermore, there is a need for Sierra Leonean environmental laws to shift away from solely relying on criminal enforcement to moving towards enhancing effective administrative and civil practices for environmental violations. It is recognised that corruption is systemic and requires national level attention. However, the Water Fund can employ certain measures to deal with the problem of encroachment and the issuance of illegal land titles. For example, fencing the WAPNP and using appropriate and clear signage would prevent these illegal activities from occurring within the Park to a large degree. While this is not a long-term solution in terms of addressing the

overarching problem of corruption and weak policies and institutions, it provides a solution to quickly address the rampant encroachment that is currently occurring.

Establish a REDD+ project to generate co-financing
There is significant potential to fund conservation through the sale of carbon credits. REDD+ provides an incentive for forest owners (in this case the government of Sierra Leone) to ensure their forest is protected and kept intact. The findings from a project undertaken in 2012 found that REDD+ for the WAPNP could be feasible and should be explored for implementation. Based on the carbon mitigation potential of the forests of the WAPNP, it is estimated that the total potential revenue from the sale of carbon credits could be between US$239 400 and US$520 800 per year. Given that a REDD+ project currently exists in the Gola Rainforest National Park, a national REDD+ program in Sierra Leone would be worth pursuing.

Potential extent of interventions under a Conservation scenario

The Conservation scenario included

- 12 556 hectares of forest restoration through active planting (1489 ha), assisted natural regeneration (3938 ha) and passive regeneration (7129 ha);
- 1152 hectares of agroforestry in buffer areas of the WAPNP;
- 53 hectares of riparian buffer zones outside of the WAPNP;
- 90 km of fencing around the entire park;
- Removal of all illegal activities, and radically-improved park management.

This would require an initial investment cost of US$6.82 million plus ongoing annual costs of some US$828 000 per year.

Return on investments in water security

The investments, expected effect, and resulting returns in terms of water security benefits are summarised in Figure II. The different outcomes relative to a BAU scenario were estimated in physical terms based on hydrological modelling, and valued in terms of avoided costs.

In Freetown, a number of low-income residents rely on unprotected wells as well as rivers and streams for their daily water needs. However, in the dry season months (December to April) people are sometimes forced to find an alternative, which usually involves purchasing water from informal vendors. Dry season flows were about 11 000 m^3 more under the Conservation scenario than under the BAU scenario, amounting to an estimated annual cost saving to poor households of US$436 941 per year.

The forests of the WAPNP are important for soil erosion control, trapping sediments and preventing them from entering the Guma and Congo water supply reservoirs that are situated within the WAPNP. These reservoirs are essential for supplying water to Freetown during the dry season between December and April when only 11-17% of the annual river discharge occurs. Under the BAU scenario it was estimated that the Guma reservoir would be completely filled with sediments within 20 years. The Conservation interventions extend the lifetime of the Guma reservoir by 55 years and the Congo reservoir by 35 years when compared to the BAU. A total of 8 812 tonnes of sediment would be prevented from reaching the dams each year relative to the BAU, saving dredging costs of US$311 000 per year for the Congo Dam and US$531 500 per year for Guma Dam. If this were the single objective of the Conservation scenario, then the return on investment would be about **111 tonnes/US$1000**. This is about ten times higher than if the problem were solved by dredging (**10 tonnes/US$1000)**.

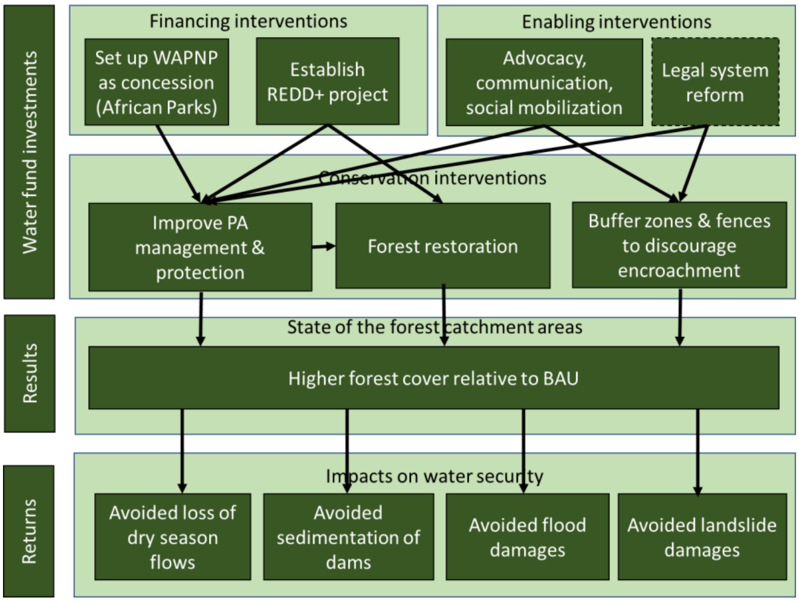

Figure II. Schematic diagram showing the different types of interventions and how they relate to the expected water security benefits.

Flooding is the most common type of natural disaster in the country, occurring frequently during the rainy season between the months of May and October. In general forest cover in catchment areas can play a major role in mitigating flood risk. However, Freetown experiences extremely high rainfall, and there is very little that either vegetation or man-made structures can do to mitigate this. The most cost-effective solution is to avoid building in flood plain areas, and very importantly, to plan for the fact that floodplain areas will expand as the urban area expands, because of the effect of hardened surfaces on flows. TNC focuses on funding nature-based solutions, and perhaps engineering solutions that help to protect nature as well as contributing to water security. Here the only nature-based solution would be to protect the floodplain areas in their entirety as natural areas. In Freetown, it is too late to do that, however.

It was estimated that the interventions under the Conservation scenario (mostly well above the urban area), would reduce the expected annual damage costs from flooding across all seven watersheds by some US$2.05 million, with an average annual reduction of 74 buildings being inundated compared to the BAU scenario. The average number of buildings inundated each year was highest in the Alligator watershed, but overall expected annual losses were highest in the Lumley watershed. This results in a return on investment of US$1.65 for every US$1 invested in restoration activities.

Freetown is also prone to landslides, which are triggered by high levels of intense rainfall over short periods of time and exacerbated by human activities such as encroachment into the WAPNP. Deforestation increases landslide hazard. While the impact of deforestation on landslides was not modelled during this study, a recent landslide risk and hazard assessment by The World Bank in Freetown estimated the average annual losses to be in the order of US$360 000, with an average of 11 fatalities of 140 people affected.

Net present value including co-benefits of the Conservation scenarios

In Sierra Leone, tourism is largely underdeveloped but has over the last decade shown positive signs of growth. However, the protected areas currently generate a very small percentage of the overall attraction-based tourism value in the country. The total attraction-based tourism value (in terms of direct contribution to GDP) in 2019 for Sierra Leone was estimated to be US$23.3 million. Based on empirical evidence of tourist activity (photo densities) about US$0.5 million or 2.2% of this national value can be attributed to the WAPNP, with a per hectare value of US$27. The WAPNP is endowed with a variety of unique and special fauna and flora, and is well positioned to attract tourists.

Under the BAU scenario, without any intervention to protect the forests of the WAPNP and promote ecotourism, it was assumed that tourism would continue to follow current trends in tourism growth. Under the Conservation scenario, where interventions are in place to protect the forest and promote ecotourism through private tourism concessions, the per hectare value of the WAPNP was assumed to increase, reaching values by 2050 that are seen in similar forest parks elsewhere in Africa. Gombe National Park in Tanzania was used as a target value where the nature-based tourism value is estimated to be US$230 per hectare, eight times higher than that of the WAPNP. Gombe makes for a good comparison as to what the WAPNP could generate in the future if protected and promoted as a unique ecotourism destination. Given that the WAPNP is more easily accessed compared to Gombe, there is even more reason to believe that higher values can be achieved in the long-term. Using this as a target value, nature-based tourism associated with the WAPNP was assumed to grow at a rate of 7% per year under the Conservation scenario. In 2050 this would generate a total of US$1.36 million under the BAU and US$3.92 million under the Conservation scenario, a difference of US$2.56 million per year.

Tropical forests play a critical role in the global carbon cycle. Based on global datasets derived from satellite data, it was estimated that approximately 12.6 million tonnes of carbon are stored within the vegetation and soils of the WAPNP, ranging from 42.6 t/ha to 1024.3 t/ha, with a mean value of 690 t/ha. The total global damage costs avoided by retaining this stock of biomass carbon is substantial at just over US$1.1 billion per year and the avoided damage cost to Sierra Leone was estimated to be just under US$0.25 million per year.

A BAU scenario would result in an estimated loss of 5115 ha of forest from the WAPNP, equating to 3.53 million tonnes of carbon. The Conservation scenario, involving strict protection of the existing forest plus restoration of 12 556 ha of forest. The loss in forest under the BAU would result in global climate-related damages of US$312 million per year and national damages of some US$70 000 per year. The Conservation intervention would avert these damages and result in an additional gain of over 8.6 million tonnes of carbon, thus avoiding global damage costs of US$765 million and some US$170 000 to Sierra Leone.

The strict protection and restoration of the WAPNP would lead to an improvement in its flora and fauna, which is something that many members of society, even beyond Sierra Leone, would value. These kinds of values, referred to in the literature as non-use or existence values, are intangible and difficult to quantify, even with best-practice stated preference methods. The WAPNP is very important from a conservation perspective, e.g. as a habitat for rare and endangered species such as the Western Chimpanzee. While this study has not attempted to estimate existence value, this benefit is likely to be very significant and should be acknowledged.

Cost-benefit analysis

The Conservation scenario was evaluated using a cost-benefit analysis to quantify the present value return on investment (ROI, net welfare gains per US$ invested) and net benefits. The costs and benefits were analysed over a time period of 30 years at a social discount rate of 3.99%. This was further tested under varying assumptions of costs, benefits and discount rate.

The results of the cost-benefit analysis suggest that the implementation of restoration interventions in and around the WAPNP would result in a net benefit for the Conservation scenario (Table I). The net present value over 30 years was estimated to be US$34.76 million, with a ROI of 2.7. In other words, every" 1 US$ invested on average would generate a return of just under US$3 in terms of benefits to stakeholders. The results presented here include the avoided national costs in terms of carbon storage and not the avoided global costs which are orders of magnitude greater. Including the global cost savings in the cost-benefit analysis would result in a net present value in the order of US$13 billion.

The results from the sensitivity analysis strongly suggest that restoration interventions in and around the WAPNP can be justified in economic terms when enabling conditions are in place to ensure their success. Under varying assumptions of costs and benefits and timing and discount rates, the results remain favourable. However, if enforcement is not strengthened and there is poor advocacy, communication and social mobilisation (as under the BAU), then the results show a negative NPV and a ROI of less than one due to the failure of ensuring adequate protection of the forests.   While the net benefits remain positive under varying assumptions, the overall viability of the Water Fund is sensitive to changes in the timing of benefits as well as in terms of the costs of interventions. Furthermore, the success of the Water Fund is largely dependent on enabling interventions that require improvement and strengthening at national and sub-national levels to ensure compliance of environmental laws. Without drastically strengthened enforcement, it is likely that a BAU approach will continue into the future. It will therefore be useful to introduce supporting interventions such as public-private partnerships and REDD+ (benefitting the park authority) to ensure the success of the project and spillover benefits to surrounding communities.

Table I. Present value of the costs of interventions and value of ecosystem service benefits for the Conservation scenario (2020 US$ millions, 3.99% discount rate, 30 years).

	Present value (US$ millions)
Costs	**Conservation Scenario**
Improved management of WAPNP	2.94
Active planting (restoration) in WAPNP	5.12
Assisted natural forest regeneration in WAPNP	3.72
Passive forest regeneration in WAPNP	6.17
Agroforestry PES	0.29
Fencing	1.54
Riparian buffer zones	0.17
Total present value of costs	**19.96**
Benefits	
Erosion control	12.30
Flood attenuation	24.69
Flow regulation	5.27
Carbon retention and gains relative to BAU (savings to Sierra Leone)	2.81
Nature-based tourism	9.50
Agroforestry gains from tree introductions	0.15
Total present value of benefits	**54.72**
Net Present Value	**34.76**
ROI	**2.7**

Conclusions

Even though we were not able to quantify all the potential benefits, the results from the cost-benefit analysis demonstrate a clear economic basis for the establishment of the Western Area Peninsula Water Fund. Overall, a US$20 million investment in restoration interventions under the Conservation scenario is expected to return at least US$55 million in economic benefits over the 30-year timeframe. In other words, every US$1 invested by the Water Fund is expected to generate at least US$2.70 of benefits to stakeholders. Furthermore, catchment restoration is significantly more cost-effective than other conventional interventions. In addition to security in water supply and mitigation of flooding and landslide risk, restoration of the WAPNP forests brings wider benefits in terms of nature-based tourism, climate change resilience, job creation, opportunities for women and most importantly, avoiding the irreversible loss of the unique and valuable biodiversity of the Upper Guinean forest. Sensitivity analysis shows that even under lower benefit and higher costs streams, as well as varying timing and discount rates, economic viability can still be maintained. However, this requires the assurance of adequate enabling conditions, which when removed, result in a negative NPV and BAU trajectory.

The following key results demonstrate the importance of protecting and restoring the forests of the WAPNP and clearly demonstrate the feasibility of establishing the Water Fund. Compared to a business-as-usual scenario:

- About 11 000 m^3 more water would be available to households during the dry season months with an annual cost saving to poor households of US$436 941 per year;
- The amount of sediments entering the rivers of the Western Area Peninsula would be halved, and the lifetime of Guma and Congo reservoirs will be 55 and 35 years longer, respectively;
- Average annual flood damages across the seven urban watersheds would be reduced by US$2.05 million, and the risks of landslides would likely be reduced;
- Gains in nature-based tourism value of the WAPNP could amount to US$3.92 million per annum;
- Carbon stored in the WAP would be 8.6 million tonnes higher, avoiding annual climate change damages of US$170 000 to Sierra Leone and of US$765 million at a global level;
- The more intensive management of the WAPNP, growth in high-end tourism and agroforestry interventions could bring significant employment and livelihood benefits to households living in the WAP.

Enabling interventions are critical for the success of the Water Fund. This will include clear communication on the need for and long-term benefits of some of the necessary strict protection measures in order to get buy-in from all stakeholders

1 Introduction

Freetown, the capital city of Sierra Leone, has experienced significant growth over the last decade. The city, designed for only 400 000 inhabitants, is now home to more than 1.2 million residents, with this figure rising each year (CRS, 2018). As a result, the city has expanded to accommodate a growing population, with increasing rates of urbanization and agricultural expansion. This has led to extensive encroachment of settlements and farming areas into the Western Area Peninsula National Park (WAPNP) causing loss and degradation of intact forest. Forest degradation has also resulted from the collection of woody resources, charcoal production and mining activities. The degradation and loss of forest is continuing at an increasing pace, placing one of the country's most valuable natural assets under imminent threat.

The remaining protected forests of the WAP are important for a range of regulating and cultural services including sediment retention, water supply, reduction of flood and landslide risks, carbon storage and biodiversity. As such they are important for water security (Box 1) and as a buffer against climate change and the economic challenges that come with it.

Box 1. Water security

The United Nations defines **water security** as: "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality of water for sustaining livelihoods, human wellbeing, and socio-economic development, for ensuring protection against water-borne pollution and water related disasters and for the preservation of ecosystems in a climate of peace and political stability" (Soto Rios *et al.* 2018). There are four core elements within this definition:

- People have access to safe adequate quantities of acceptable quality drinking water for sustaining livelihoods, human well-being, and socio-economic development. Water supply needs to be adequate and reliable, and typically piped to people's homes and places of work;
- Water is available for economic activities and development, energy production, industry and transport as required, and people's livelihoods are not affected by unreliable water supplies;
- Ecosystems are preserved such that they deliver water related ecosystem services. This includes that protection of freshwater resources, and the aesthetic and recreational opportunities associated with aquatic ecosystems and human-made reservoirs; and
- Climate related water hazards, such as floods and droughts, and the risks associated with these, are effectively managed.

Critically, the forest area of the WAPNP protects soil cover in the catchment areas of the city's two main water supply dams (NWRMA, 2019). There are more than 50 water catchments across the Western Area Peninsula and over 90% of them are located within the WAPNP (NWRMA, 2019). Water supply to the city of Freetown is mainly from the Guma reservoir, which supplies 1.5 million people, and the Congo reservoir, which supplies 300 000 people (Guma Valley Water Company, 2008). Deforestation allows soil to be washed into the dams, reducing their storage capacity and increasing water treatment costs.

The forest ecosystem also plays a role in capturing rainfall and aiding its infiltration, which helps to maintain baseflows so that water is available for use throughout the dry season. Aside from the municipal areas supplied by dams, households in the rest of the peninsula obtain their water directly from springs, rivers and streams as well as some boreholes and wells. There are numerous small weirs that supply over a million people in rural and urban communities outside of the municipal area, although these are mostly in bad condition. Deforestation increases the likelihood of these water sources running dry for part of the year.

The forest areas of the WAP are also important for protecting the downstream urban areas from flooding and landslides. Deforestation increases the volume and velocity of runoff from the catchment areas, increasing the capacity for damage. In addition, the activities that cause deforestation (all illegal within the WAPNP) also lead to a reduction in water quality as soils, agricultural pollutants and human wastes enter streams that flow into the settled areas around the park, threatening human health. Habitat loss and illegal hunting also threatens the wildlife populations that are already largely confined to the parks' limited area, such as the endangered Chimpanzee (the national animal of Sierra Leone), potentially undermining the tourism and recreational value of the park as well as its global value.

Urgent action is needed to protect this critical natural resource and in particular to invest in nature-based solutions to ensure sustainability for future generations. To this end, the Catholic Relief Services (CRS) in partnership with The Nature Conservancy (TNC) through the *Replenish Africa Initiative* funding by the Coca Cola Foundation aims to develop a business case for the investment in proposed **nature-based solutions** for the WAPNP as well as to engage with key stakeholders to get their support for the prioritisation of investments. The development of the Western Area Peninsula Water Fund is just one of a handful of Water Funds that are in development across Africa. This follows the successful establishment of the Upper Tana-Nairobi Water Fund in Kenya in 2015 and the launch of the Greater Cape Town Water Fund in South Africa in 2018, both of which put forward ecological infrastructure restoration as critical components to enhancing water security in their respective cities. Analysis using hydrological modelling demonstrated that such measures can be significantly more cost-effective than alternative, conventional interventions.

The aim of this study was to determine the economic value of the difference in priority ecosystem services flows between a "business as usual" scenario and a "conservation" scenario which is facilitated by a Western Area Peninsula Water Fund (WAPWF), and analyse these benefits in relation to the costs of implementation to determine the net present value (NPV), return on investment (ROI), and cost-effectiveness of the Conservation scenario, based on an analytical framework developed by TNC (Figure 1.1).

The terms of reference for the study can be summarised as follows:

1. **Evaluate the potential feasibility of a range of potential conservation interventions**, such as greenbelts, park guard training, reforestation, alternative livelihoods, policies to curb illegal issuing of land title, education and communication, and low impact development designs to capture sediments, improve water quality and mitigate flooding, based on a review of their potential efficacy, costs and social acceptability.
2. **Compile a conservation scenario** in which nature-based interventions are located at priority sites that would likely yield the greatest net benefits, but considering spatial variation in cost-effectiveness; this to be submitted to the hydrologic modelling teams.

3. **Estimate the cost of the conservation scenario**, including the costs of design, installation, overhead expenses, management, maintenance and repairs, monitoring, opportunity costs to landowners, incentive or compensation payments, and transaction costs, e.g. in drawing up, monitoring and enforcing agreements.
4. **Calculate the cost effectiveness and ROI of the WAPWF in terms of the water security objectives** (expressed in physical terms) – increased dry season water supply (m^3/a), reduced TSS in water abstracted by households or treated by the public utility, reduced number of flooded structures. Cost effectiveness to be determined both individually (as single objectives) to evaluate whether conservation is cost-competitive with alternative, conventional solutions, and collectively (multiple objectives) in which costs are compared to a bundle of alternative, conventional interventions that provide this suite of target outcomes (by assigning a share of the conservation scenario to each target outcome). Return on investment to be calculated on the basis of the cost to achieve the same outcomes as the Conservation scenario using the least costly conventional interventions.
5. **Calculate the NPV of the WAPWF taking other benefits into account,** such as biodiversity, carbon sequestration and storage, or food security.

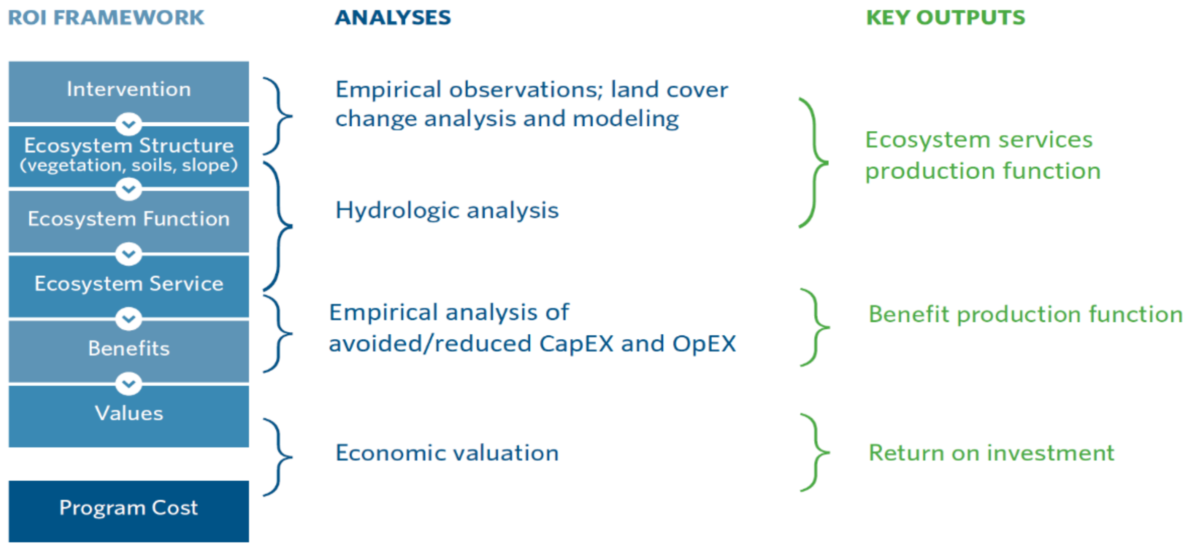

Figure 1.1. ROI framework for green infrastructure assessments (adapted from Kroeger et al., 2017)

The study was carried out by Anchor Environmental Consultants, South Africa with inputs on the hydrological and hydraulic modelling of the BAU and Conservation scenarios from The Nature Conservancy (Baker & Srinivasan, 2020) and Villanova University, USA (Smith & Cotugno, 2020; Smith, Shugart-Schmidt & Cotugno, 2020), and inputs on conventional engineering costs from Zutari, South Africa. The development of the Conservation scenario included input from the National Water Resources Management Agency (NWRMA), Catholic Relief Services (CRS) and Guma Valley Water Company.

2 Potential forest degradation under a BAU scenario

2.1 Rate and drivers of forest degradation and loss

Global forest loss has remained alarmingly high during the last decades and threats and losses continue to be reported. Between 2000 and 2012, 2.14 million km^2 of global forest was lost, with over 10% of the total forest lost occurring within protected areas, equating to 3% of the total protected forest (Heino *et al.*, 2015). The main direct drivers of global deforestation are linked to agriculture, logging, infrastructure expansion and livestock grazing (Geist & Lambin, 2002; Lawlor *et al.*, 2009; Defries *et al.*, 2010; Hosonuma *et al.*, 2012; Busch & Ferretti-Gallon, 2017; Scullion *et al.*, 2019). Insecure property rights, weak governance, pro-development policies and institutional failures are important indirect drivers of forest loss (Lawlor *et al.*, 2009; Busch & Ferretti-Gallon, 2017; Scullion *et al.*, 2019). In tropical Africa, the expansion of subsistence agriculture, population growth and urban expansion, and mining activities are the main deforestation drivers, with fuelwood collection and charcoal production being the main degradation driver (Boahene, 1998; Hosonuma *et al.*, 2012; Busch & Ferretti-Gallon, 2017; Scullion *et al.*, 2019; Seymour & Harris, 2019).

Forest loss, or deforestation, is defined as the long-term or permanent conversion of land from forest use to other non-forest uses. **Forest degradation** is a direct, human-induced, long-term loss or reduction in forest carbon stocks, not recognised as deforestation (Sedano et al. 2016). **Both are due to human activities and do not happen naturally.**

Freetown has experienced significant land cover change over the last two decades (ÖBf, 2012; Mansaray, Huang & Kamara, 2016). Between 2000 and 2011, 420 ha of forest were lost annually on the Western Area Peninsula, an annual rate of 0.8% (ÖBf, 2012). This is higher than the global annual rate of 0.4% estimated by the FAO for primary forests over the same period (2000-2010, FAO, 2010). Deforestation on the peninsula doubled from 3% (0.5% annually) between 2000 and 2006 to 6% (1.2% annually) from 2006 to 2011 (ÖBf, 2012). By that time, almost of all the change detected by remote sensing was due to deforestation, and not degradation. However, the poor resolution of the imagery at the time would not have been very good for detecting forest degradation (ÖBf, 2012).

We analysed the change in canopy cover across the WAPNP from 2000-2015 using the Global Forest Cover Change (GFCC) Tree Cover Multi-Year 30 metre dataset[1]. Over this period, 10 587 hectares of forest experienced some thinning or loss of canopy cover, equating to an overall loss of 2103 ha of forest (Figure 2.1). This is an average loss of 140 ha per year. A total of 41 hectares of forest within the National Park lost 60-80% canopy cover from 2000 to 2015, 806 hectares of forest lost 40-60% canopy cover and just over 4 000 hectares had canopy loss of between 20 and 40%. The remainder (5659 ha) lost 1-20% canopy cover.

[1] Note that there were many missing values in the 2015 layer, which means that our estimates are conservative.

Closer inspection of the data shows a shift in the density of the forest canopy in the WAPNP (Figure 2.2). The distribution of the area of forest within each canopy cover band has changed significantly since 2000 where much of the forest had a canopy cover close to 60%, with some areas reaching as high as 83% canopy cover. In 2005, this distribution changed with a shift to lower canopy cover classes, with most of the forest falling within the 20-40% cover band. This pattern has continued and by 2015 the highest canopy cover recorded across the park was 64%. This suggests that there has been loss in canopy cover as well as a thinning out of the canopy, analogous to high levels of degradation.

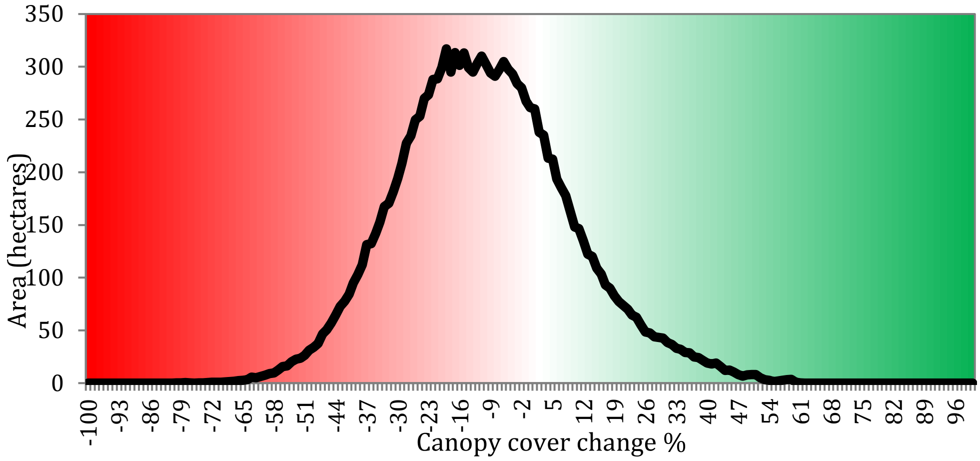

Figure 2.1. The total area (hectares) of forest canopy cover change (%) from 2000-2015 in the Western Area Peninsula National Park. The negative values indicate the % loss in canopy cover and the positive values the % gain in canopy cover.

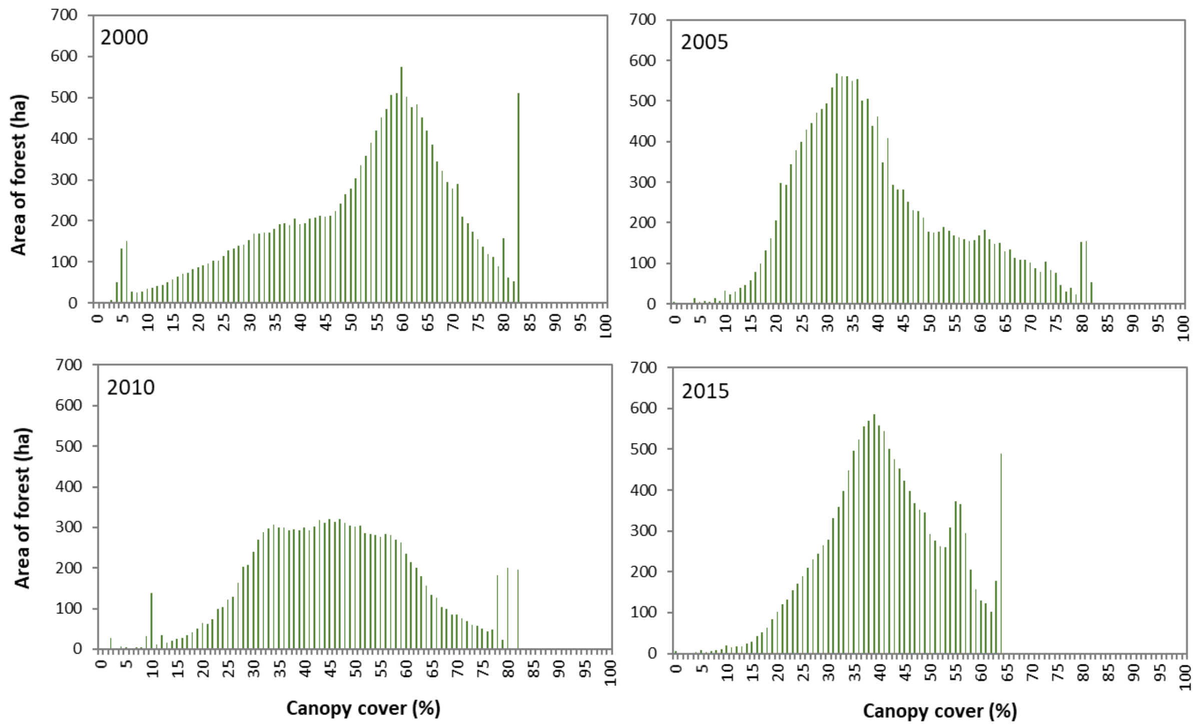

Figure 2.2. The area of forest (in hectares) within each canopy cover band for the period 2000-2015 in the Western Area Peninsula National Park. Data source: Global Forest Cover Change (GFCC) Tree Cover Multi-Year 30 metre dataset.

The most serious driver of forest loss within the WAPNP is urban area expansion (Figure 2.3). Shifting agriculture, fuelwood harvesting and charcoal production, stone quarrying, illegal logging, and marijuana farming also lead to forest degradation and loss (ÖBf, 2012; Figure 2.3, Figure 2.4). Important indirect drivers of forest degradation and loss are rural-urban migration, poor law enforcement, corruption, conflicting government mandates and poverty.

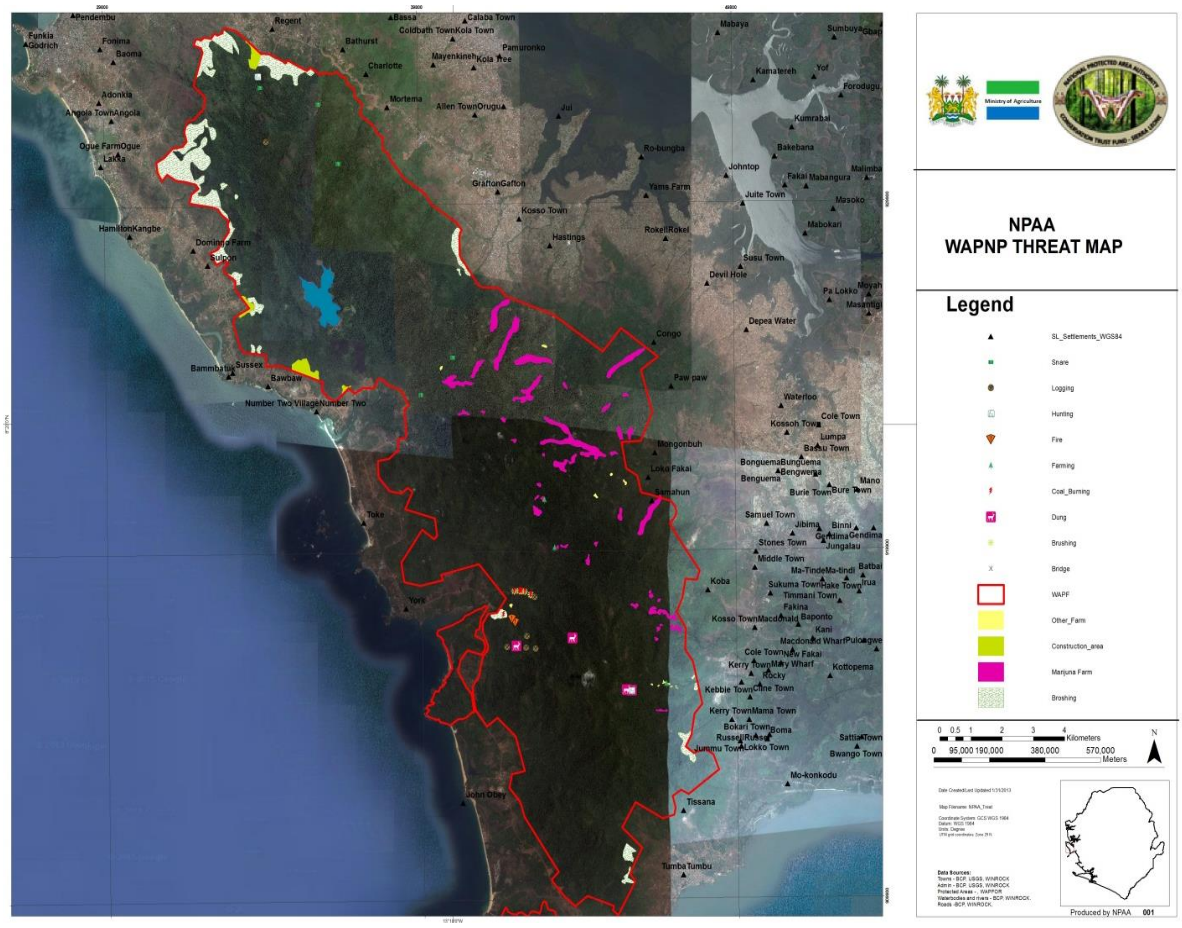

Figure 2.3. National Protected Area Authority (NPAA) WAPNP threat map. Source: NPAA

Figure 2.4. Illegal marijuana plantations within the Western Area Peninsula National Park. Source: NPAA (2017).

An earlier study estimated that by 2011, approximately 3 200 ha of forest within the protected forest reserve had been encroached by human settlement, with most of this occurring on the northern peak with the expansion of Freetown (WHH, 2011). At the time, it was estimated that some 100 000 residents lived in areas that had been forested only ten years prior. There are also extensive marijuana plantations and some smaller agricultural activities taking place. Along the boundary of the Park, particularly in the northern sections, land is being encroached or "brushed"[2], either for agricultural activities or for construction purposes. Poaching and the use of snares seems to be more common in the northern sections of the Park.

Fuelwood harvesting and charcoal production has led to significant loss of forest cover. Over the past two decades there has been an unprecedented increase in the commercial trading of fuelwood products in Sierra Leone, with the vast majority of small scale charcoal production having been initiated since the turn of the century (Munro & van der Horst, 2012). In Freetown, firewood used to be the primary source of energy for cooking, but this has been taken over by charcoal, with 73% of households using charcoal by 2013 (Table 2.1, Fayiah, Dong & Singh, 2018). This is an annual growth rate of 9% since 2004. Kerosene was being used by more than 10% of households in 2004 but by 2013 this had dropped to less than 1%. The absence of electricity in homes, especially for cooking, and a preference for charcoal as a cooking fuel has strengthened the demand for charcoal across the country (Munro & van der Horst, 2012; Fayiah *et al.*, 2018a). This trend has been reinforced by landlords asking tenants to cook with charcoal instead of firewood to reduce smoke damage and fire hazards, as well as by the invention of the Wonder Stove (see westwindenergy.sl), an energy efficient cookstove that reduces the amount of charcoal needed for cooking by about 60% (Munro & van der Horst, 2012). The latter is a good example of what is known as the "rebound effect" that happens when introducing more efficient energy technologies in an unconstrained supply situation.

Table 2.1. The population of Freetown and % household primary energy source for cooking, 1963-2013. Source: Fayiah et al., 2018

Year	Freetown population	National population	Freetown as % of national	% Freetown household primary energy source					
				Charcoal	Wood	Kerosene	LPG	Elec.	Others
1963	127 917	2 180 355	5.9	1.0	91.0	7.0	-	-	-
1975	276 247	2 735 159	10.1	18.0	68.0	12.0	-	-	-
1989	469 776	3 515 812	13.4	30.0	60.0	8.8	-	-	-
2004	764 484	4 976 876	15.4	32.2	50.7	10.8	1.0	0.1	5.2
2013	1 019 744	5 989 623	17.0	72.7	26.0	0.6	0.2	0.05	0.5

Charcoal is produced illegally within the WAPNP. A recent article in 2019, explains that each illegal charcoal pit in the protected forest uses about 40 trees and can produce more than 11 tonnes of charcoal, worth around US$800 (see https://www.gcca.eu/stories/trail-sierra-leones-illegal-charcoal-burners). While some of the urban charcoal demand is supplied from the WAPNP, most still came from outside of city as of around 2011 (Munro & van der Horst, 2012). The districts of Kambia and Port Loko which are situated north-east of Freetown were identified as the main areas of production. Charcoal is also sourced from the districts of

[2] Brushing refers to the clearing of land through felling of trees and burning (slash and burn)

Moyamba (south-east), Tonkolili (east) and Bombali (north-east). Logging and charcoal production activities appear to be prevalent in the south-western section of the park.

In the fishing village of Tombo, wood is harvested from the forest to smoke fish. It has been estimated that about 8 000 bundles of firewood are used per day to smoke fish, equating to more than 100 000 trees per year (WHH, 2011). Recent satellite imagery shows that the town of Tomba has expanded significantly since 2011, with noticeable deforestation into the adjacent WAPNP.

2.2 Predicted land cover change under BAU

An analysis of land cover change using Normalized Difference Vegetation Index (NDVI) data by Smith *et al.* (2020) has shown that over a twenty-year period from 2001 to 2020 the remaining area under natural vegetation on the WAP declined from 72% to 63%. Using the NDVI analysis and translating this onto the Sentinel land cover, a land cover as of 2050 was generated for the BAU scenario. Urban areas of the Western Area Peninsula are predicted to increase by 197% between 2015 and 2050, with significant encroachment into the WAPNP. By 2050 it is estimated that there will be a loss of 5 115 hectares of forest from within the WAPNP, just less than one third of current forest cover.

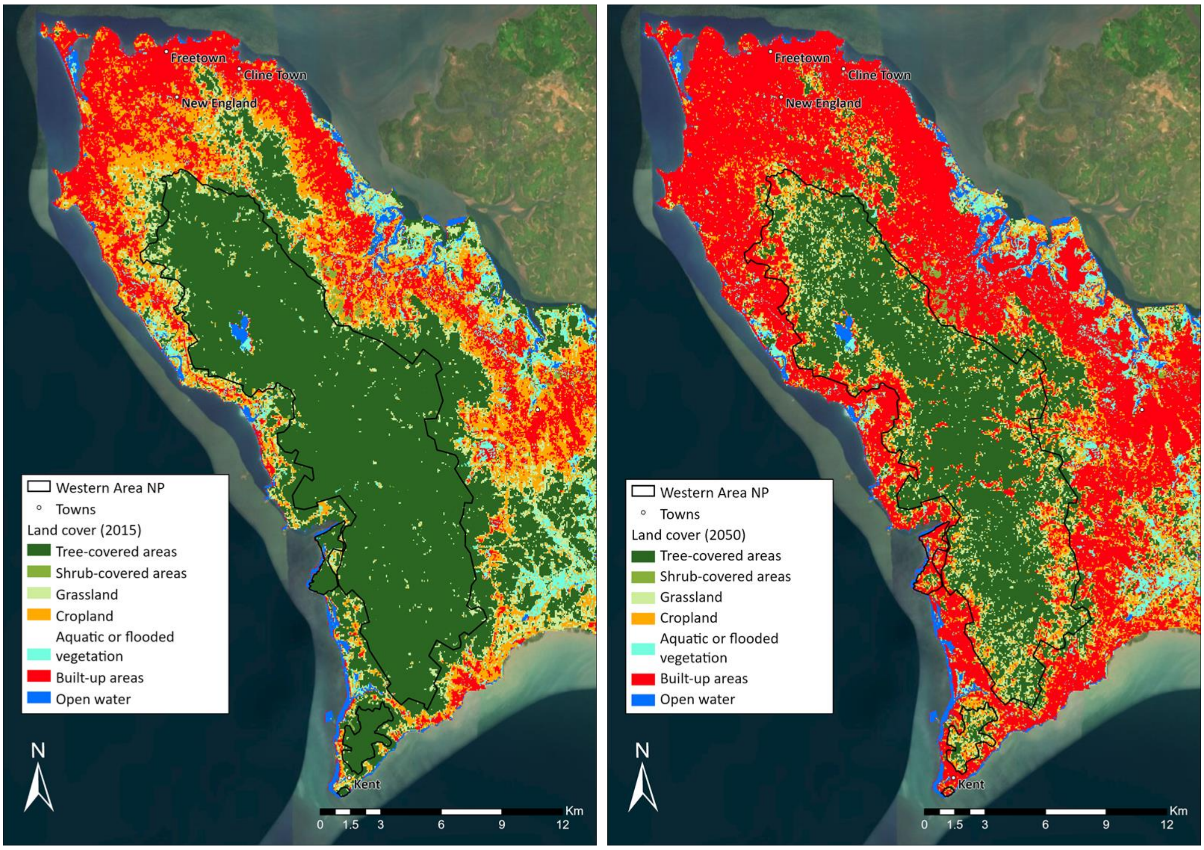

Figure 2.5. Past (2015) and projected (2050) land cover for the Western Area Peninsula. The 2050 land cover was used for the BAU scenario.

3 Identification of conservation interventions

3.1 Overview

The focus of this study is on improving water security for the Freetown area relative to the BAU using nature-based interventions. The main options to be considered would be aimed at halting and reversing the deforestation that has taken place in the WAPNP as well as to preserve or restore forest areas in the riparian zones of the urbanised areas below the park, with a view to retaining or improving the regulation of flows and retention of sediments, in particular.

This task involved an extensive desktop review of potential forest restoration interventions, based on studies conducted elsewhere in the region (and globally), to get a better understanding of the factors affecting their success in different socio-ecological contexts. We first start with a short review of recent meta-analyses of the drivers of deforestation and the interventions and policies that have been found to reduce it. We then move onto reviewing the proposed conservation interventions. This also included collating information on the various costs of different interventions.

Scullion *et al.* (2019) and Busch & Ferretti-Gallon (2017) studied the relative influence of different drivers of forest loss and degradation and explored the interventions that stem it through quantitative meta-analyses. Hundreds of spatially explicit econometric studies on forest loss and degradation were examined to determine which types of interventions best conserve forests and prevent degradation. Both studies show that a wide range of policies and strategies exist to protect forests and that there is no one single intervention seen as the panacea for stemming forest loss. Rather, given the fact that many interventions are specialised and effective only under specific conditions, an *intelligent combination* of policy options is preferred for effecting change. Their findings suggest that one needs a mix of interventions that are directly aimed at forest conservation and supporting or enabling interventions.

Active interventions would include strict controls (e.g. effective protected areas), mechanisms to incentivise conservation actions (e.g. payments for ecosystem services), and mechanisms to reduce the demand for damaging activities (e.g. agricultural reforms), as well as restoration activities that are feasible in areas treated under the first two.

- **Protected areas**: Designed to prevent land use change, protected areas are a mainstay of biodiversity conservation. There is ample evidence proving that protected areas slow or stop deforestation compared to unprotected areas. However, their efficacy depends on the extent and intensity of nearby development, as well as the density of park guards. However, their success is often challenged where institutions and political support are weak (Busch & Ferretti-Gallon, 2017; Scullion *et al.*, 2019).
- **Payments for ecosystem services (PES)**: Over the past decade PES programs have become increasingly popular as a forest conservation strategy. They come in a variety of forms, including reducing emissions from deforestation and degradation (REDD+) and can be implemented as a stand-alone intervention or in combination with protected areas (Sims & Alix-Garcia, 2017). While there have been mixed reviews on their success, PES programs can provide a strong incentive to conserve forests and can reduce

deforestation. However, their success is dependent on effective law enforcement and stable public institutions.

- **Agricultural reforms**: Given that agricultural expansion is one of the leading causes of deforestation, reforming the agricultural sector is seen as a crucial forest conservation strategy. Agricultural policies designed to reduce forest loss include "supply chain interventions", such as crop certification schemes, commodity roundtables and corporate procurement policies. While these policies focus more on the industrial expansion of agriculture, in Africa strategies are needed to reduce the impacts of shifting smallholder agriculture.

Supporting interventions include mechanisms to gain political, government and community support (e.g. political advocacy, education, capacity and awareness raising), to enable more effective law enforcement (e.g. to address systemic issues such as capacity, corruption, judicial and legal structures and facilities), to improve cooperative landscape management (e.g. through agreements and bylaws), and of course to mechanisms to ensure the sustainable financing of all of the above. Three commonly considered types of interventions are as follows:

- **Cooperative landscape management**: This is a collaborative management approach and can include combinations of protected areas, working forests and agricultural landscapes (Scullion *et al.*, 2019). A number of conservation interventions can be implemented through this approach, such as deforestation bans and moratoriums, forest zoning, land tenure reforms and strategic road planning (Laurance *et al.*, 2014; Busch & Ferretti-Gallon, 2017).
- **Enforcement**: Weak or absent law enforcement is the most frequently reported institutional failure in Africa (Scullion *et al.*, 2019). This is concerning given that enforcement of rules and regulations underlying natural resource management is necessary for conservation success. Indeed, effective law enforcement is associated with positive forest conservation outcomes (Agrawal, Wollenberg & Persha, 2014).
- **Political advocacy**: Political advocacy is crucial for forest conservation. It is needed to generate political will and ensure government transparency. An engaged population is also important for conserving forests because ultimately human behaviour is the cause of most conservation challenges (Schultz, 2011).

In this study, the area of interest is largely within an existing proclaimed protected area, although there are also some areas outside of the WAPNP which could potentially provide valuable services, notably the riparian zones. Other than those, the areas immediately around the park could also usefully be managed as buffer zones to help strengthen the park. Thus, this study has not included a review of payments for ecosystem services (PES) where payments are made to local communities. It does consider REDD+ as a financing option, however, where the government or park management authority would be the recipient.

3.2 Interventions to retain and recover forest

3.2.1 Effective protection of the WAPNP

Protected areas are the cornerstone of biodiversity protection and a central component of conservation strategies. There is ample evidence proving that protected areas can slow or stop deforestation compared to unprotected areas. However, their efficacy depends on the extent and intensity of nearby development, as well as the density of park guards. In addition, their success is often challenged where institutions and political support are weak (Busch & Ferretti-Gallon, 2017; Scullion *et al.*, 2019).

Protected areas in the tropics have shown to be effective at preventing or slowing deforestation (Bruner *et al.*, 2001; Andam *et al.*, 2008; Ferraro, Hanauer & Sims, 2011; Spracklen *et al.*, 2015; Sims & Alix-Garcia, 2017; Scullion *et al.*, 2019). However, park effectiveness in developing countries is jeopardized by severe underfunding. As a result, management and enforcement is not sufficient and illegal activities continue unabated. Effective law enforcement is crucial for achieving positive forest conservation outcomes.

Park guards are a critical component of protected area management. Research by Bruner *et al.*, (2001) who investigated the effectiveness of parks in protecting tropical biodiversity found that park effectiveness correlated most strongly with the **density of guards**. In the 15 most effective parks the density of park guards was eight times higher than in the 15 least effective parks (3 guards per 100 km^2 versus 0.4 guards per 100 km^2). The study also found that many of the park staff lacked critical training and equipment to adequately carry out their duties. The density of park guards required to effectively protect a park is a function of the size of the park, its location and accessibility, as well as other factors such as the types and densities of wildlife in the park.

Estimates of required funding for effective park management vary from US$192 to US$467 per km^2 for forest parks in Central Africa (mean of US$314, Blom, 2004) to US$500 per km^2 for parks Africa-wide (Bell & Clarke, 1984). More recently, Lindsey *et al.* (2018) estimated that an annual minimum funding requirement of between US$1090 and US$2180 per km^2 is necessary for protected areas in Africa to effectively conserve lions (all values here are in 2019 US$). The African Parks model is estimated to have a management cost of close to US$1000 per km^2 per year.

In Sierra Leone, the protected area network covers just under 5% of the country and lacks adequate management and enforcement (UNEP, 2010). In fact, a global analysis of deforestation in moist tropical forest protected areas found that Sierra Leone (amongst other countries) has the worst performing protected areas based on forest loss over the period 2000–2012 (Spracklen *et al.*, 2015). Thus, strengthening their protected area systems is a high priority nationally as well as in the WAP. Effective protected area management was also identified in the REDD+ scoping report as necessary to reduce and avoid any further encroachment and deforestation, in order for a REDD+ project to be a workable option for the Western Area Peninsula (ÖBf, 2012).

Situated on the edge of the city of Freetown and surrounded by urban and peri-urban communities, the WAPNP is easily accessible. As such, it is expected to require a relatively high density of guards in order to offer effective protection to its forests and wildlife. Currently there are an estimated 300 park guards employed in the WAPNP (Ministry of Environment, pers. comm.). However, there seems to be some uncertainty about this. According to the National Protected Area Authority (NPAA), the WAPNP is zoned into ten patrol areas, each of which have about 15 to 20 guards. However, staff turnover is reportedly high and the number of guards on the ground patrolling varies considerably from month to month. Furthermore, information from the Ministry of Environment and the NPAA suggest that enforcement is compromised by corrupt guards who receive bribes from people wanting to access land or resources in the park. The NPAA is currently recruiting a further 500 game guards to complement efforts across the entire protected area network in Sierra Leone. The monthly salary of a park guard is reported to be around US$125 (Ministry of Environment, pers. comm). The training of park guards is reported to be costly and is generally provided by the Department for International Development (DFID) and the International Security Advisory Team (ISAT). Currently, the only source of revenue for Parks in Sierra Leone is through government subsidies and occasional interventions by the Conservation Trust Fund. As a result, the funding shortfall for protected areas is significant. In 1996, Sierra Leone's protected area network covered 1744 km^2 and the total park budget was US$22 716, with no capital investment and an estimated funding shortfall of US$2 million (see James, Green & Paine, 1999). Based on the information from the Ministry of Environment it appears that since the end of the civil war in 2002 not much has changed and protected areas continue to be severely underfinanced. Apart from increasing the number of staff and improving their retention rate, training and capacity building will also be important for increasing management effectiveness.

In addition, maintaining effectiveness requires ongoing monitoring. This should be through the use of the Management Effectiveness Tracking Tool (METT), a simple scorecard that facilitates rapid assessment. The METT helps park managers and donors to identify needs, constraints and priority actions to improve the effectiveness of protected area management. It can be used for donor evaluation, to improve management and for accountability, all of which are vitally important, especially if the park is receiving or applying for donor funding. Also, protected areas that are designated under international conventions such as UNESCO World Heritage, are required to undertake such reporting, in order to maintain transparency and accountability. METT is the most widely applied protected area management effectiveness (PAME) tool globally, used in 127 countries accounting for more than one fifth of the world's terrestrial protected area coverage (Stolton *et al.*, 2019). The wide uptake of METT has been driven by the fact that it is relatively simple and cheap to use and can be easily adapted at the national level by protected area agencies and the like, as well as it being used and promoted by WWF, The World Bank, and the Global Environment Facility (GEF).

In order for the park to achieve its conservation objectives, the revamp of the park will also require the elimination of existing illegal activities, including production of charcoal, marijuana and other crop production. These activities not only cause deforestation but also contribute towards water pollution and sedimentation problems (NWRMA, 2019). The recent NWRMA report outlines these issues at a catchment level, providing detailed descriptions of the extent and impact of activities in each water supply catchment (see NWRMA, 2019). The total area of illegal agriculture within the WAPNP is about 147 hectares, which should also be targeted for active restoration (see below). Providing the particular individuals involved in these activities with alternative livelihoods is not seen as a workable option to reducing the impact of these activities in the National Park. In fact, it is likely that such an intervention would lead to rent-seeking activities[3] and an even greater problem of heightened illegal activities. Rather, people operating illegally within the WAPNP need to be removed, and preferably arrested and prosecuted or at least let off with a warning of the consequences of reoffending. Rather than giving advance notice, e.g. to allow for the next harvest, the timing of the swoop should allow for this.

In areas where the houses have already been constructed within the WAPNP, and title deeds to the land have been sold to the encroachers, then the most suitable option would be to **buy-out** these individuals and moving forward ensure the enforcement of development setbacks. Demolition of the structures would send a clear message. This would require the inter-ministerial cooperation where the police, and the ministry of lands country planning and the environment work together to eradicate illegal operations and prevent encroachment or the selling of land within the demarcated protected area. The costs of this would depend on the number of title deeds already sold within the Park and associated buy-out costs.

Given the context and systemic problems experienced in Sierra Leone, it is likely that the creation of an efficient protected area will require the outsourcing of management to a reputable international private entity such as African Parks. Based on above, the WAPNP was estimated to require an additional US$1 000 per km^2 per year in order to become effectively managed. Given that the park is only 170 km^2, this equates to a total cost of US$170 000 per year (Table 3.1).

Table 3.1. The activities and cost of improving protected area management in the WAPNP

Intervention	Extent (km^2)	Activities	Unit cost (US$/$km^2$/y)
Improve protected area management	170	Increased number of guards in the field, improved training and equipment for effective patrolling and enforcement, development of a METT scorecard system for the park	1 000

Finally, the effectiveness of the protected area can also be improved through the installation of fencing. Fences are an effective tool for preventing encroachment into protected areas and reducing illegal activities such as poaching and logging (Pekor *et al.*, 2019). The use of fencing as a method to protect Parks in densely populated areas in Africa is becoming increasingly important and more widespread (Lindsey *et al.*, 2012; Pekor *et al.*, 2019). This is especially the case in West Africa, where bushmeat hunting and encroachment are two of the biggest threats to protected areas. Indeed, a recent survey of experts found that support for protected area fencing was highest in West Africa where experts, all of which were associated with unfenced

3 These are activities that aim to obtain financial gains and benefits through the manipulation of the distribution of economic resources, where individuals move into an area if they believe they will be "rewarded" for taking part in certain activities.

protected areas (n=10), indicated their preference for the use of fencing (Pekor *et al.*, 2019). Fencing all or part of the Western Area Peninsula National Park, which is surrounded by a growing urban population, is a highly relevant management tool that has numerous benefits. These include demarcation and a reduction in encroachment, easing of management and on the ground security/patrolling, containing wildlife for protection, and preventing poaching (Pekor *et al.*, 2019). As a conservation intervention we recommend that the use of fencing be explored initially between the National Park and the agroforestry buffer zones. This would cover the entire boundary of the park (90 km). Given the relatively small size of the National Park, the total cost of fencing is not excessive (US$855 000). Estimates for the cost of fencing were extracted from Pekor *et al.* (2019) based on data collected from 63 partially or fully-fenced protected areas in 10 countries. The unit cost of fence construction is US$9 500 per km, with an estimated annual inspection and maintenance budget of US$490 per km of fence.

Table 3.2. The cost of installing fencing around the WAPNP

Intervention	Extent	Activities	Unit cost
Fully fenced National Park	90 km	Fence surrounding entire National Park	US$ 9 500 /km
		Annual inspection and maintenance	US$490 /km/year

The improvement of protected area management to safeguard the forests of the WAPNP will benefit the residents of Freetown and other smaller towns on the peninsula in the long term through water supply improvements, flood and landslide mitigation and tourism development opportunities. Investment into employing more park guards will provide employment opportunities and improved training will strengthen and upskill existing park personnel.

3.2.2 Forest restoration within the WAPNP

The purpose of forest restoration is to re-establish ecological properties which accelerate recovery of forest structure, biodiversity, and ecological functioning toward the pre-disturbance, or 'reference' state (Chazdon & Uriarte, 2016). This can be achieved through **active restoration** or through **assisted natural regeneration**. The two restoration measures differ in their approach and in cost.

Active restoration involves the planting of seedlings, direct seeding, and/or the manipulation of disturbance regimes, such as fire, to encourage faster recovery (Crouzeilles *et al.*, 2017). The tree species that are planted (or encouraged to establish) are those that provide a critical ecological function in the target ecosystem. In contrast, natural regeneration is a biological process whereby new forest establishes itself and recovers some or all of its ecological functions (FAO, 2019). Spontaneous (or passive) natural regeneration occurs without any human intervention, whereas **assisted natural regeneration (ANR)** refers to the set of interventions that are employed to accelerate the natural regeneration of forests, through weeding, fire prevention, attracting seed dispersal, and fencing to control livestock grazing and other disturbances (Crouzeilles *et al.*, 2017).

Active restoration through tree planting continues to remain the major focus of restoration programs, even though there is rapidly growing evidence of the feasibility and economic and environmental benefits of natural regeneration (Chazdon & Guariguata, 2016; Chazdon & Uriarte, 2016; Crouzeilles *et al.*, 2017, 2020; Brancalion *et al.*, 2019). This is because, until recently, its potential to promote restoration at scale has been poorly understood (Crouzeilles *et al.*, 2020). However, studies show that natural regeneration is not only a more cost-effective measure but also that it surpasses active restoration in achieving tropical forest restoration success (Crouzeilles *et al.*, 2017; Brancalion *et al.*, 2019). Indeed, there is evidence that natural regeneration is more effective than tree planting at achieving the recovery of biodiversity and forest structure (Crouzeilles *et al.*, 2017). As a result, natural regeneration, both passive and assisted, is increasingly being recognised as a cost-effective option for upscaling restoration in tropical regions in order to achieve global (and national) restoration commitments. Under favourable conditions ANR has the ability to greatly reduce implementation costs and thus larger areas can be targeted (Chazdon & Guariguata, 2016).

This is not to say that active restoration does not have a place. By prioritizing ANR activities in appropriate areas, limited funds and labour can be better allocated for active restoration in areas where ANR activities are not suitable and tree planting is necessary for restoring forest cover (FAO, 2019). ANR can also be combined with enrichment planting, also called "mixed restoration", which is useful in areas with patchy or low levels of naturally regenerating tree seedlings (FAO, 2019). The advantages and limitations of active restoration and assisted natural regeneration are outlined in Table 3.3.

Table 3.3. The advantages and limitations of active forest restoration and assisted natural regeneration. Source: Crouzeilles et al., 2017; FAO, 2019

	Active restoration (planting)	Assisted natural regeneration
Advantages	• Can create diverse habitat through the introduction of thousands of seedlings • In some areas, active restoration is the only suitable approach (where land degradation or the opportunity cost of land is high, or the land is far from forest remnant patches). • Can support higher direct economic returns, usually in the form of wood products	• Low-cost, low-tech approach • Plant community that establishes is well adapted to site conditions • Generates a diverse, mixed vegetative structure • Ecological restoration success is higher than active reforestation • Flexible and adaptive
Limitations	• High-cost, high-tech approach • Tree species used in planting often lack full range of functional traits found in natural regrowth forests	• Soil conditions need to be favourable • Natural regenerants need to be present in sufficiently high densities in order to rapidly build up canopy cover • Enrichment planting may be required if large seed-dispersing animal species have been eradicated

Forest restoration is a complex activity and estimating the costs of such activities is very difficult, given the many site- and country-specific factors that influence cost (Chazdon & Uriarte, 2016; Brancalion *et al.*, 2019; FAO, 2019). Labour costs, transportation, and material costs, accessibility of the site, extent of the area to be restored, density of planting required, frequency of maintenance, and time needed to achieve canopy closure, all influence overall restoration costs. Costs vary widely between active restoration and natural regeneration (passive and assisted), with active restoration being significantly more costly than natural regeneration due to higher input costs. In fact, under appropriate conditions, ANR can reduce implementation costs by more than 70% compared to active restoration that uses full tree planting (Crouzeilles *et al.*, 2020).

In assessing the restoration costs for the three most widespread forest biomes in Brazil and in estimating the restoration costs associated with implementing Brazil's National Plan for Native Vegetation Recovery, natural regeneration and assisted natural regeneration approaches were found to be an order of magnitude cheaper than active restoration approaches (Brancalion *et al.*, 2019). Active restoration interventions which include some degree of site preparation, weed control, planting and active maintenance of seedlings are the most expensive, with per-hectare costs for full planting interventions ranging from US$1 400 to US$6 600 (Chazdon & Uriarte, 2016). Others have reported that these costs can be as high as US$34 000 per hectare (Crouzeilles *et al.*, 2017). Direct seeding is less costly than full planting. Brancalion *et al.* (2019) estimated the mean cost of full planting to be US$2 328 per ha, direct seeding S$1 754 per ha, enrichment planting US$788 per ha, assisted natural regeneration US$344 per ha and natural regeneration US$49 per ha. In that study, the only expense for natural regeneration was site protection against disturbance, weed control was the dominant expense for assisted natural regeneration, and direct seeding and/or seedling planting were the major costs for active planting (Brancalion *et al.*, 2019). Total establishment costs for environmental plantings in Australia were found to range from US$1 703 per ha to US$9 097 per ha, with a mean of US$4 364 per ha (Summers *et al.*, 2015). The per hectare costs of ANR implementation in the Philippines were found to be US$579, compared to US$1 048 per hectare using active restoration methods (Dugan, 2011).

We estimated the maximum potential extent of active restoration and assisted natural regeneration interventions in the WAPNP based on spatial data on the extent of degradation. Unit costs were taken from the literature (Table 3.4). Restoration sites require constant maintenance, especially for the first 6 years of establishment. Maintenance costs are usually between 10% and 15% of implementation costs. In this study the upper end of 15% was used.

Forest protection and restoration is critical for improving water supply, retaining sediments and mitigating the effects of flooding in the urban areas of Freetown. Furthermore, it is important for reducing the risks associated with landslides. This has far-reaching benefits for the residents of Freetown and also for those peri-urban and rural communities of the Western Area Peninsula. Flooding and landslides are a frequent occurrence in Freetown and the restoration and preservation of forested land has shown to be effective in reducing these risks through reduced peak flows and stabilisation of soils, the benefits of which are felt by those residents living in the flood-prone urban areas of the city. Infiltration and regulation of flows during the dry season months is also an important benefit that would be felt by a number of communities around the Peninsula where low-income residents collect water from rivers and streams. It is also important in terms of providing flows during the dry season to the Guma and Conga reservoirs, which supply water to the residents of Freetown. This intervention also has the opportunity for job creation. Active planting and assisted natural regeneration requires intensive labour and with large areas of forest targeted for restoration with maintenance and monitoring occurring over a six year period a dedicated restoration team would need to be employed, providing employment opportunities for unskilled labourers.

Table 3.4. The estimated unit cost (US$/ha) and the potential maximum extent (ha) of forest restoration interventions in the Western Area Peninsula National Park.

Intervention	Activities	Appropriate conditions	Unit cost (US$/ha)	Potential extent (ha)
Active restoration (planting & direct seeding)	Soil preparation, direct seeding, seedling planting, weed control, protection against disturbances, maintenance	In degraded areas where tree canopy cover loss has been more than 40%, where density of naturally regenerated tree seedlings is not adequate for ANR activities.	2 000	1 500
Assisted natural regeneration	Weed control, protection against disturbances, maintenance	Degraded areas with remnant forest cover, in buffer zones of protected area, steep slopes, biological corridors where density of naturally regenerated tree seedlings is adequate and where tree canopy cover loss has been between 20% and 40%.	550	3 950
(Passive) natural regeneration	Protection against disturbances	Degraded areas with remnant forest cover where density of naturally regenerated tree seedlings is adequate and where tree canopy cover loss has been less than 20%.	50/y	7 200

3.2.3 Agroforestry buffer zones between urban edge and park boundary

The delineation of buffer zones around core forest areas can be an important tool in both conserving areas of ecological importance and addressing development objectives (Atsri *et al.*, 2019). Multi-use buffer zones surrounding a protected area serve the purpose of protecting forest resources by providing ecological buffering functions whilst providing resources such as fuelwood or areas for agricultural activities.

Buffer zones around parks are conventionally thought of as areas that are retained in a natural state (an extension of the protected habitats), but in which certain extractive activities are allowed. These areas function as physical barriers to human encroachment, reduce illegal extraction and reduce ecological edge effects, and therefore help to secure ecosystem services provided by the protected area (Robinson, Albers & Busby, 2013; Atsri *et al.*, 2019). There are a number of studies that have shown that buffers can reduce deforestation and degradation (Nagendra *et al.*, 2004; Scullion *et al.*, 2014; Weisse & Naughton-Treves, 2016). However, there are also studies that have found buffers to be ineffective at protecting forests (e.g. Kintz, Young & Crews-Meyer, 2006; Mehring & Stoll-Kleemann, 2011). Indeed, the effectiveness of buffer zones increase with buffer area width (Robinson *et al.*, 2013), as well as being influenced by the level of enforcement of activities allowed in the buffer.

In the case of the WAP, deforestation has already progressed to the WAPNP boundary and in some areas has already progressed well into the park. There is limited remaining opportunity to retain a forested buffer area around the park as described above, especially given the high human densities in the WAP. However, given the relatively small size of the WAPNP and the high levels of urban development surrounding the park, some kind of buffer may be crucial to the conservation of biodiversity and ecosystem services supplied by the WAPNP. A buffer zone around the WAPNP would need to have significant tree cover in order to be effective. Restoration of forest areas in a buffer zone is technically possible but will take considerable time, and may not be feasible given the pressure for land and economic opportunities. Therefore, it is proposed that an *agroforestry buffer zone* is developed between the intensively modified areas and the WAPNP boundary as far as possible.

Agroforestry is a form of production system where trees are grown among crops or pastureland (Current, Lutz & Scherr, 1995). In areas where deforestation occurs due to clearing for crops, this practice is often encouraged to retain some tree cover in the areas being deforested, and hence reduce losses of carbon and biodiversity (Steffan-Dewenter *et al.*, 2007). In other areas, agroforestry is introduced to already-cleared areas in order to restore some of these public benefits. Either way, there is usually a trade-off involved, in that adopting agroforestry practices usually involves compromising on private benefits. While many private benefits can be obtained by the tree crops, the yields of the main crops are typically reduced (Wade *et al.*, 2010; Tschora & Cherubini, 2020). Thus, agroforestry practices might have to be incentivised, for example through payments for ecosystem services (PES) schemes. Indeed, setting up agroforestry in already-deforested areas would require upfront investment of time, resources and secure land tenure (Benjamin & Sauer, 2018). As long as the opportunity costs (reduced yields due to shading) are covered (see Wunder, 2005), agroforestry PES schemes can have numerous benefits to smallholder farmers (Benjamin & Sauer, 2018).

Agroforestry provides a relatively inexpensive and feasible opportunity for providing employment and food security, as well as numerous environmental benefits. While initial costs may be high, the longer terms gains to society outweigh the initial capital investments (Franzel, 2005). Depending on the design of the agroforestry system (the mix of tree and crop types), the trade-offs can be minimised (Tschora & Cherubini, 2020). In some cases, agroforestry provides opportunities for landowners to diversify their production systems and can even be more profitable and less labour intensive than conventional farming practices (Alavalapati & Mercer, 2005; Ajayi *et al.*, 2009). On the Peninsula the agroforestry system would be based on the intentional integration of (fast-growing) trees and shrubs into crop farming for the purpose of providing fruit, fuelwood, fodder, and timber, among other services (Alavalapati & Mercer, 2005). A benefit of agroforestry is that it can be undertaken at various scales, from small household gardens which are less than a hectare in size to larger landscape levels covering hundreds of hectares. It is also suitable for implementation in both rural and peri-urban environments. Care needs to be taken to ensure the any trees planted as part of the agroforestry system are not alien or invasive.

According to Sierra Leone's 6th National Report for the Convention on Biological Diversity, more than 200 000 tree seedlings were planted in buffer zones identified under the REDD+ Project, and the number is increasing as a result of agroforestry practices by the Ministry of Agriculture, Forestry, and Food Security (MAFFS). This is encouraging and suggests that the mechanisms (e.g. a supportive policy framework) are already in place to further develop agroforestry and buffer zones across the Peninsula. The buffer zones would not necessarily need to be implemented around the entire Park, rather in areas where illegal activities are known to pose a threat to the core forest area.

Introducing agroforestry systems across the Peninsula will require engagement between government and local communities in order to generate buy-in and to provide the necessary information about how people can benefit from these systems. It is envisaged that agroforestry should be implemented in areas where there is clear land ownership in order for the benefits to accrue to those that invest in conservation activities. Agroforestry systems can be set up as low-cost systems, with minimal inputs, that provide a diversity of products and that provide significant opportunities to women who usually are unable to afford high cost agricultural technologies due to cash and credit constraints (Kiptot & Franzel, 2011). Landowners or prospective landowners that volunteer to participate in the scheme would be selected on the basis of a competitive bidding system, in order to maximise the efficiency and extent of the intervention under a limited budget. Much research has been conducted on the best ways to set this up (e.g. on reverse auctions).

In terms of location, a number of areas surrounding the WAPNP were identified as potential agroforestry buffer zones, covering a total area of 1 152 hectares under maximum implementation. These areas are scattered around the Peninsula, providing opportunities for increased incomes and sustainable livelihoods. Space for agricultural activities is limited in Freetown with these designated agroforestry areas providing opportunity for more extensive agricultural gardens and woodlots.

The cash requirements for agroforestry are relatively small, mainly restricted to the purchasing of seedlings, labour, and fertilizer costs, but likely beyond the means of many landowners. Based on information from the literature (Alavalapati & Mercer, 2005; Franzel, 2005; Torres *et al.*, 2010; Cedrez *et al.*, 2020) the estimated cost per hectare for establishing an integrated agroforestry system is US$150 (Table 3.5). In addition to assistance with set up costs, the establishment of the buffer zone will also require a payment scheme in which landowners are rewarded for increases in forest cover as well as for ongoing retention of cover. In a well-designed system in which opportunity costs are covered by a PES, this should generate net benefits to farmers over and above the former land use from access to a range of resources from the agroforestry trees. In Kenya, a similar such scheme involved an average PES of about $10/ha/year (Benjamin & Sauer, 2018).

Table 3.5. The cost of establishing agroforestry buffer zones around the WAPNP

Intervention	Potential extent	Activities	Unit cost
Agroforestry PES	1 152 ha	Set up costs	150 US$/ha
		Recurring incentive payments	10 US$/ha/year

3.2.4 Riparian buffer zones

Riparian buffer zones are natural or semi-natural vegetated areas along rivers and streams that contribute to water security by intercepting sediments, nutrients, pesticides, and litter in unchanneled surface runoff, thereby reducing the amount of pollutants entering rivers and streams. They can also help to attenuate peak flood flows and reduce potential geomorphic activity that poses risks to human life, infrastructure, and ecosystems. Assuming appropriate vegetation types, riparian buffers can also be important for reducing surface erosion and providing river bank stabilisation, both by reducing the velocity of overbank runoff from adjacent areas and by anchoring the soil and reducing near-bank velocities of water in the channel, through increased channel roughness. They also provide habitat and linear wildlife corridors through the landscape – increasingly important functions as adjacent areas are sterilised by urban development.

In this study we investigated the potential effects of establishing riparian buffers zones which might comprise conserved linear forested areas and/or multi-use zones that are compatible with the functions described above. This would involve rehabilitation and enhancement of riparian zones extending about 30 m from the channel. On the Western Area Peninsula there are a number of watersheds with extensive sections of river that are severely degraded, with eroded banks, and the riparian vegetation either completely removed or in poor condition (e.g. Lumley Creek watershed, Babador River, Orogu River). The riparian buffer zones are situated in the upper catchment areas of the northern peak section of the Peninsula, above the largest urban areas. Costs of rehabilitation of riparian buffer areas vary greatly depending on specific site conditions and the level of degradation. If rehabilitation only includes seeding and planting, then the costs involved are relatively low per hectare. However, these areas would require some landscaping or earth grading as well as seedling protection, which can increase the costs significantly. Based on projects carried out elsewhere, restoration of the riparian zone, including seeding and planting, would be expected to cost approximately **$2 350 per ha** (Table 3.6).

Table 3.6. The activities and cost of establishing multi-use riparian buffer zones

Intervention	Activities	Unit cost	Potential extent (ha)
Multi-use riparian buffer zones	Landscaping, earth grading, seeding, and planting	US$ 2 350 per ha	53

3.3 Enabling interventions

3.3.1 Advocacy, communication and social mobilisation

Political advocacy is crucial for forest conservation. Without buy-in and the political will to change current systems from those at the top levels of government, conservation effectiveness is limited. Weak governance, institutional failure, and corruption are serious challenges to effective park management and can inhibit implementation of conservation interventions and disrupt desired effects (Scullion *et al.*, 2019). Indeed, lack of political will, lack of inter-ministerial cooperation and a lack of cooperation from local authorities have been cited in the WAPNP Status Report (NPAA, 2017) as main challenges that require immediate attention. There will be a need to further investigate potential models of advocacy that can harmonise interests and priorities, especially among water, land and environmental conservation.

The loss and degradation of natural ecosystems is mostly caused by human activities. Any efforts to promote conservation must therefore also focus on changing human behaviour (Schultz, 2011), and may not be viewed favourably, especially when it involves restrictions of individual freedoms, even though this is "for the greater good". Awareness raising and social mobilization are critical for protection of the WAP forests. Social acceptability is an important enabling condition for achieving successful restoration. The acceptance of interventions by the communities of the Western Area Peninsula is important for ensuring their success in the long-term. While there are groups of people that are likely to lose out in the short-term, such as those that are illegally harvesting forestry products (e.g. fuelwood and bush meat) and will be prevented from doing so through the construction of a fence and increased security, the overall gains from forest restoration in the long-term will outweigh these short-term losses. Agroforestry zones and the development of tourism will contribute towards improving livelihoods and increasing opportunities for employment, especially for women. Furthermore, the protection and restoration of the forests and the development of a Water Fund will contribute strongly to ensuring water security for the rural and urban communities of the Western Area Peninsula. Awareness and social mobilization will be critical for promoting the Water Fund and generating awareness about the importance of the forests for water security and how the Water Fund can generate community benefits in the long-term.

Research by (Schultz, 2011) indicates that motivation is the driving force behind changing behaviour and any efforts to educate the public must include a motivational element, i.e. a reason for action, in addition to education campaigns. Furthermore, results from the research suggest that messages that focus on single, achievable and specific actions are more likely to succeed, rather than broad, generic appeals to “save the planet” or “protect the forests” which are generally ineffective at changing behaviour (Schultz, 2011). Therefore, raising awareness of specific policies, laws and regulations that relate to the protection and management of natural areas and how these policies relate to improving livelihoods and water security. Indeed, water security as it relates to providing all people with reliable, safe water and sanitation services in rural and urban communities of the WAP is of critical importance to the proposed Water Fund and should be the leading motivation for social behaviour change.

Such a campaign is important for generating awareness about the Western Area Peninsular Water Fund, the Western Area Peninsula forests and the associated economic value of the forest in terms of the ecosystem goods and services that they provide to the people of Freetown, e.g. through improved water supply. A focused campaign highlighting specific actions with regards to water security will be important for motivating change.

Based on information from the Ministry of Environment on previous outreach and communication programs (e.g. videos, jingles, tv programs, banners, radio discussions, signposts, workshops, symposia, and community engagements), the cost of advocacy, communication and social mobilisation was estimated to be **US$15 000 per year**.

3.3.2 Enforcement of existing laws

Enforcement of the law is a vital component of any regulatory system. The major challenges facing Sierra Leone in terms of environmental compliance and enforcement include weak policies and institutions, ministerial mandate overlap, corruption, weak monitoring and an absence of inter-sectorial coordination amongst government agencies (Fayiah, Otesile & Mattia, 2018b). Currently enforcement is severely lacking and hindering protected area management. The illegal activities undertaken within the park, particularly the encroachment in the northern areas, demonstrates a lack of political will as well as limited resources to enforce the National

Protected Area Authority and Conservation Trust Fund Act (2012). Improved inter-ministerial cooperation and improved cooperation from local authorities is needed. The recently established inter-ministerial committee is as a step in the right direction (Caroline Raes, CRS, pers. comm.). Furthermore, there is a need for Sierra Leonean environmental laws to shift away from solely relying on criminal enforcement to moving towards enhancing effective administrative and civil practices for environmental violations (UNEP, 2014).

Administrative enforcement: Actions that are carried out by regulatory institutions to ensure compliance with environmental requirements. This could include, for example, issuance of permits or Environmental Impact Assessments. Decisions on monetary sanctions and cancellation of permits can be undertaken at the administrative level. This requires strengthening coordination and cooperation between ministries and agencies, as well as appropriate training and adequate inspection to monitor compliance.

Civil enforcement: The use of civil or alternate actions to ensure compliance and enforcement, usually through the involvement of non-governmental actors with environmental expertise, e.g. public interest organisations and the like. Civil society can assist government in environmental enforcement through sharing of information about environmental crime or be involved through community-based monitoring programmes.

Criminal enforcement: The most common form of enforcement is to impose criminal sanctions. However, these sanctions are often not very effective, especially in countries with overburdened criminal justice systems. Environmental law is cross-cutting and therefore requires coordination and cooperation from a wide variety of government agencies and ministries.

We recognise that corruption is systemic and requires national level attention. However, the Water Fund can employ certain measures to deal with the problem of encroachment and the issuance of illegal land titles. For example, fencing the WAPNP and using appropriate and clear signage would prevent these illegal activities from occurring within the Park. While this is not a long-term solution in terms of addressing the overarching challenges at a national level, it provides a solution to quickly address the rampant encroachment that is currently occurring.

3.4 Interventions to raise co-financing/reduce costs

The Water Fund is a financial mechanism that is used to fund conservation measures within water-supply catchments. The funding mechanism, inherent in the water fund model, pools investment across multiple public and private water users, with a common goal of restoring the surface water catchments that supply water to urban and rural communities. The interventions described here to rase co-financing or reduce costs is in addition to the standard Water Fund funding mechanism of public-private partnership.

3.4.1 REDD+

Economic mechanisms and incentives, especially payments for ecosystem services (PES), are increasingly being recognised as a way of strengthening conservation, improving livelihoods, and generating revenue outside of the state budget for conservation. PES is defined as a voluntary transaction where a well-defined ecosystem service is being bought by a minimum of one beneficiary (buyer) from a minimum of one provider (seller), if and only if, the provider secures ecosystem service provision (Wunder, 2005). PES programs come in a variety of forms, including carbon payments (e.g. Reducing Emissions from Deforestation and Forest Degradation, REDD+) and payments for hydrological services. On the Western Area Peninsula, the use of a traditional PES system would not be appropriate as the forests that require protection are within a National Park and the delivery of ecosystem services from the Park are not dependent on the land use activities of a specific community. As such, a REDD+ program is seen as a potential incentive for better forest management and an opportunity for raising funds for protected area management, where the government is the forest "owner" selling carbon credits to developed countries. The income received from the sale of carbon credits could be used to finance the protection of the National Park and to fund restoration activities.

The United Nations' REDD+ system was developed to financially reward developing countries for protecting forests and in 2015 the Paris Agreement further supported the role of REDD+ in climate policy (Jayachandran *et al.*, 2017). For REDD+ to be a workable option, practical conservation interventions are needed to effectively reduce deforestation and address restoration. REDD+ provides an incentive for forest owners (in this case the government of Sierra Leone) to ensure their forest is protected and kept intact. In 2012, a scoping study was undertaken for the Western Area Peninsula Forest Reserve in order to assess the feasibility of a REDD+ project (see ÖBf, 2012 and http://www.reddprojectsdatabase.org). The findings from the project demonstrated that a REDD+ project could be feasible and should be explored for implementation. The study suggested developing the project further by using the Verified Carbon Standard (VCS), and to complement this with the Climate, Community and Biodiversity Alliance Standard (CCBS) for social and environmental issues. The "Conservation of the Western Area Peninsula Forest Reserve (WAPFR) and its Watersheds" REDD+ Project has since ended without any carbon certification or sale of carbon credits. However, its potential should be further pursued. Especially given that there is currently an operational REDD+ Project in Sierra Leone. The Gola REDD Project is a 30-year long project that was established in 2012 to conserve the forested areas of the Gola Rainforest National Park (GRNP), which are Sierra Leone's largest remaining area of Upper Guinea Tropical Forest. The project aims to preserve over 68 000 ha of tropical forest and provide livelihood support to 114 impoverished communities that surround the GRNP (see www.reddprojectsdatabase.org). The project has been certified under the CCB and VCS and has been selling carbon credits for the past four years. One of the major challenges associated with REDD+ is that of leakage, which refers to the movement of destructive activities to other locations because of REDD+ activities. A national REDD+ program in Sierra Leone is therefore seen as more favourable than having numerous REDD+ projects scattered across the country (Bayrak & Marafa, 2016).

Despite the widespread interest in PES, evidence of its effectiveness in reducing deforestation and its cost-effectiveness have remain varied (Busch & Ferretti-Gallon, 2017; Jayachandran *et al.*, 2017). However, more recently there have been some high-quality evaluations of PES that have provided rigorous evidence of their cost-effectiveness and their impact on reducing tree cover loss. Jayachandran *et al.* (2017) evaluated a program of payments for ecosystem services in Uganda and found that tree cover declined by 4.2% during the study period in treatment villages compared to 9.1% in control villages. Furthermore, there was no evidence of leakage (i.e. participants did not shift their deforestation to nearby land) and the program benefits, calculated by converting the program's effect on tree cover into delayed CO_2 emissions, were found to be 2.4 times larger than the program costs. Roopsind, Sohngen & Brandt (2019) provides the first empirical study on the impact of REDD+ implementation at the country level by evaluating a nationwide REDD+ program in Guyana. By applying synthetic matching to estimate tree cover loss that would have occurred in the absence of the national REDD+ program, the authors estimate that the program reduced tree cover loss by 35% during the program implementation period (2010-2015). The study concluded that the program met the additionality criteria of REDD+. However, they also found that tree cover loss increased after payments had ended, suggesting that without continued payments, forest protection is not guaranteed (Roopsind *et al.*, 2019). Protected areas and PES are recognised as the top two mechanisms available for countries to achieve international REDD agreements (Sims & Alix-Garcia, 2017). Empirical comparisons suggest that both policies are effective at conserving forest, generating approximately 20-25% reduction in forest cover loss (Sims & Alix-Garcia, 2017). This same study found that policies focusing on flexible zoning around protected areas in combination with sustainable financing and acknowledgement of local development goals would go further to achieving conservation goals (Sims & Alix-Garcia, 2017).

There is significant potential to fund conservation through the sale of carbon credits. Carbon projects are supported by corporations, individuals and governments who purchase carbon offsets. Markets are growing fast (Hamrick & Gallant, 2018), largely fuelled by the growing number of companies that are aiming to become carbon neutral through voluntary carbon offsets in order to satisfy public demand. Indeed, the growing demand for purchasing offsets resulted in a record high 42.8 $MtCO_2e$ (million metric tonnes of CO_2 equivalent) retired in 2018 (Hamrick & Gallant, 2018). On the voluntary market carbon offset prices can vary considerably. Ecosystem Marketplace (refer to Hamrick & Gallant, 2018) tracks offset prices and in 2018, while the average prices ranged between US$3 and US$6 per tCO_2e, actual prices were found to range from US$0.1 to US$70 per tCO_2e. In Africa the average carbon offset price in 2018 was recorded as US$4.20 per tCO_2e (Hamrick & Gallant, 2018). Preliminary findings from the "Conservation of the Western Area Peninsula Forest Reserve (WAPFR) and its Watersheds" REDD+ Project (refer to ÖBf, 2012) suggested a mitigation potential that ranged from 57 000 tCO_2e to 124 000 tCO_2e per year. Based on the average price of US$4.20 this equates to a total potential revenue from the sale of carbon credits of **US$239 400 to US$520 800 per year**.

The estimated costs involved in planning and implementing a large-scale forest carbon project (or Clean Development Mechanism) are shown in Table 3.7. A CDM allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol to implement an emission-reduction project in developing countries. These costs are based on data from the literature and market surveys, extracted from ÖBf (2012) and updated to 2019 US$.

Table 3.7. Estimated costs of planning and implementing a large-scale forest carbon project (or Clean Development Mechanism). Source: ÖBf (2012). *The registration and issuance fees are based on the number of carbon credits per year, calculated here with a minimum of 15 000 credits and a maximum of 2 million credits.

Activity	Type of cost	Min cost (US$)	Max cost (US$)
Project design	Consultancy fee or internal cost for creation of a project design document	45 200	180 800
New methodology	Consultancy fee or internal cost to review relevant methodology and update as required	45 200	113 000
Validation	Auditor fee	16 950	28 250
Registration fees*	Administrative fee	1 695	39 550
Initial verification	Auditor fee	22 600	33 900
Monitoring	Internal cost	5 650	22 600
Ongoing verification	Auditor fee	16 950	28 250
Issuance fee*	Administrative fee	1 695	452 000
TOTAL		**155 940**	**898 350**

3.4.2 Private tourism concessions

Currently, there is very limited tourism or recreational activities associated with the Western Area Peninsula National Park. There are no designated entry points to the Park, no entrance fees, no tours, and no accommodation. The Tacugama Chimpanzee Conservancy is a fenced rehabilitation sanctuary situated within the north-eastern confines of the WAPNP. This conservancy is currently the only access point to the WAPNP. The forests and the unspoiled beaches of the Western Area Peninsula are incredible environmental assets with significant potential for harnessing nature-based tourism income. Entrance fees into the Park to do guided walks to see chimpanzees or to birdwatch would provide much-needed park income and other tourism facilities in and around the Park would provide employment opportunities.

However, developing tourism in the Park would require significant funding if this were to be undertaken by National Protected Area Authority. A private concession can help to achieve protected area management goals by generating income, contributing to economic and rural development, managing illegal activities, and enhancing conservation objectives (see Box 2; UNDP, 2014). The private sector can raise funds more easily, diversifying funding sources from a reliance on government funding (World Bank, 2016).

A **concession** is a lease, permit, or license for operation within a protected area undertaken by any party other than the designated protected area agency (adapted from UNDP 2014). Concessions can be awarded through auction, tender or direct awarding.

There are a number of case studies that highlight the positive impact of private concessions on protected area management. In Rwanda, the Akagera National Park is a success story. In just under ten years the park has been rehabilitated, wildlife numbers have increased, and tourism has thrived. In 2009, the Rwanda Development Board and African Parks[4] signed a joint agreement establishing a management company for the park. An electric fence was erected to keep poachers out and to address human-wildlife conflict. Investment in the construction of two upmarket tented camps resulted in private tour operators increasingly adding Akagera to their itineraries. Since 2010 tourism revenue has increased by a staggering 1150% and the park is now 90% self-financing. African Parks has transformed numerous other protected areas across the continent, including in Malawi, Zambia, Democratic Republic of Congo, Benin and Chad.

Activities in the WAPNP and surrounding areas could include guided walks, fishing, biking, kayaking, and canoeing, and birdwatching. There is significant opportunity for a concession to bring much-needed revenue to the management of the WAPNP. Indeed, in South Africa between 2002 and 2012, tourism concessions alone generated US$58 million for South African National Parks (World Bank, 2016). Potential exists on the WAP to develop successful concession program to generate revenue for protected area management. However, it should be recognised that these forests are too ecologically sensitive for mass tourism and the focus should be on high-value, low-volume tourism, such as in Botswana and Rwanda.

Box 2. Benefits that private concessions offer protected areas. Source: UNDP (2014)

1. Provide visitor services that the protected area agency cannot afford to provide;
2. Broaden the scope of visitor services and extending these services to a larger audience;
3. Provide income for reinvestment into management or restoration activities;
4. Increase the economic value of a protected area;
5. Provide conservation awareness;
6. Advertise and market the protected area as a tourist destination;
7. Help to reduce illegal activities such as poaching through their presence within the protected area;
8. Promote economic development through employment opportunities and upskilling of local communities; and
9. Develop a positive working relationship with the protected area agency to support protected area management and the conservation of biodiversity.

---

[4] African Parks pioneered the Public-Private Partnership (PPP) model for protected area management. They maintain the full responsibility and execution of all management functions and are accountable to the government, who is the owner and who determines the policy. See www.africanparks.org

4 Potential extent of interventions under a Conservation scenario

Based on the above, the potential extents of different interventions were established to create a Conservation scenario. This included 12 556 hectares of forest restoration through active planting (1489 ha), assisted natural regeneration (3938 ha) and passive regeneration (7129 ha). Agroforestry zones surrounding the WAPNP cover a total area of 1152 hectares. An area of 53 hectares of riparian buffer was considered for rehabilitation and fencing covered the entirety of the park at a length of 90 km. All illegal activities in the National Park were removed and park management is improved, with a private concession established. A summary of the spatial extent and cost of intervention for the Conservation scenario are outlined in Table 4.1 and shown in Figure 4.1. Some of the intervention costs are on an annual basis and others include implementation costs and follow up costs (i.e. ongoing management and monitoring costs). Note that the costs of active restoration include the costs associated with restoring the areas under illegal agriculture.

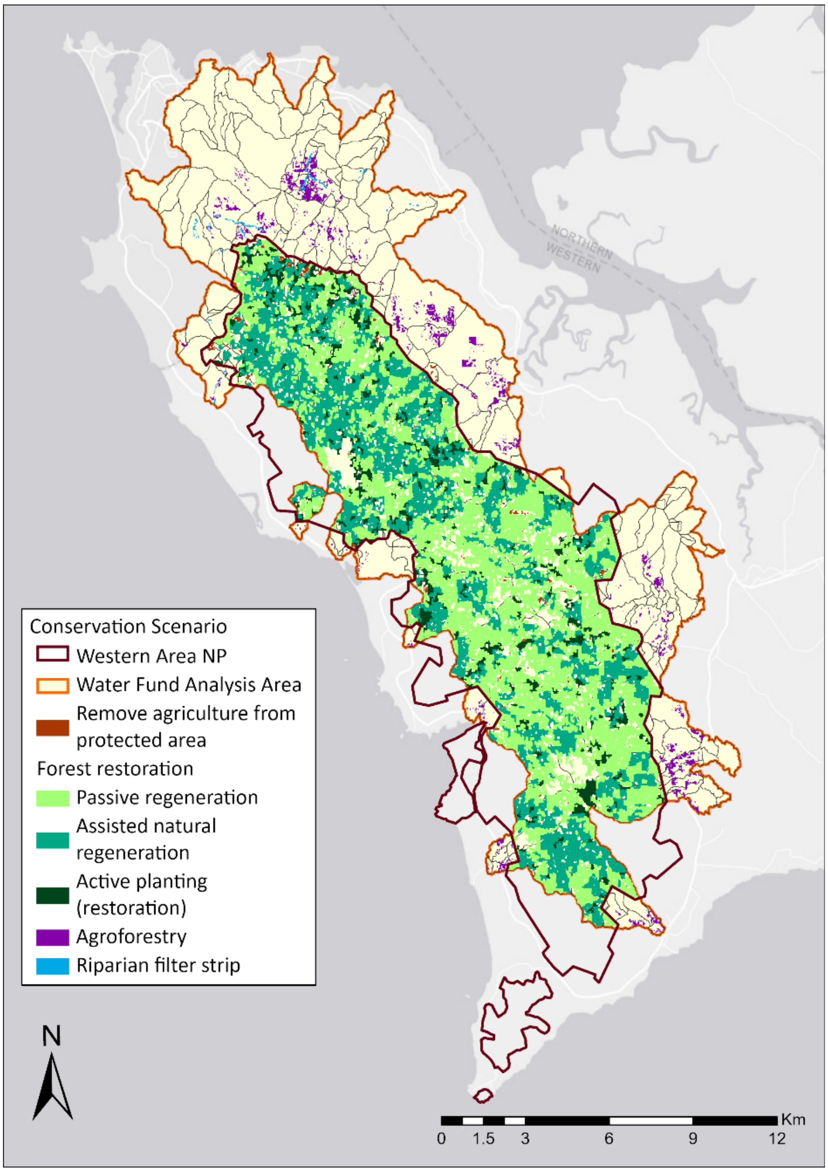

Figure 4.1. The estimated locations of the spatial interventions for the Conservation scenario. Note that this would need to be verified with detailed field observations.

Table 4.1. The extent and costs of interventions under the Conservation scenario. Note that these are indicative costs based on the literature and would need to be verified with detailed field studies and budgeting.

Intervention	Unit	Extent of intervention	Timing	Unit costs (US$)		Total costs (US$)	
				Initial	Annual thereafter	Initial	Annual thereafter*
Improved management of protected area	ha	17 000	Annual management costs	10	10	170 000	170 000
Active planting (restoration)	ha	1 489	Initial plus 6 years follow-up	2 000	300	2 978 000	446 700
Assisted natural regeneration	ha	3 938	Initial plus 6 years follow-up	550	83	2 165 900	324 885
Passive regeneration	ha	7 129	Annual management costs	50	50	356 450	356 450
Agroforestry buffer zones	ha	1 152	Initial + 15 years PES	150	10	172 800	11 520
Fencing	km	90	Initial plus annual maintenance	9 500	490	855 000	44 100
Riparian buffer zones	ha	53	Initial + 5 years follow-up	2 350	235	124 550	12 455
TOTAL US$						**6 822 700**	**1 366 110**

*For as long as stipulated under "Timing"

5 Return on investments in water security

5.1 Overview

While the study was initially conceived to examine the return on investment in interventions based on single or multiple objectives expressed in physical terms, it became apparent that it would be very difficult to separate out the effects due to the strong interdependencies of the interventions (Figure 5.1) Thus the analysis has focused on quantifying the effects of the interventions in physical and/or monetary terms, and expressing the ROI for the Conservation scenario as a whole using the monetary valuation of the benefits.

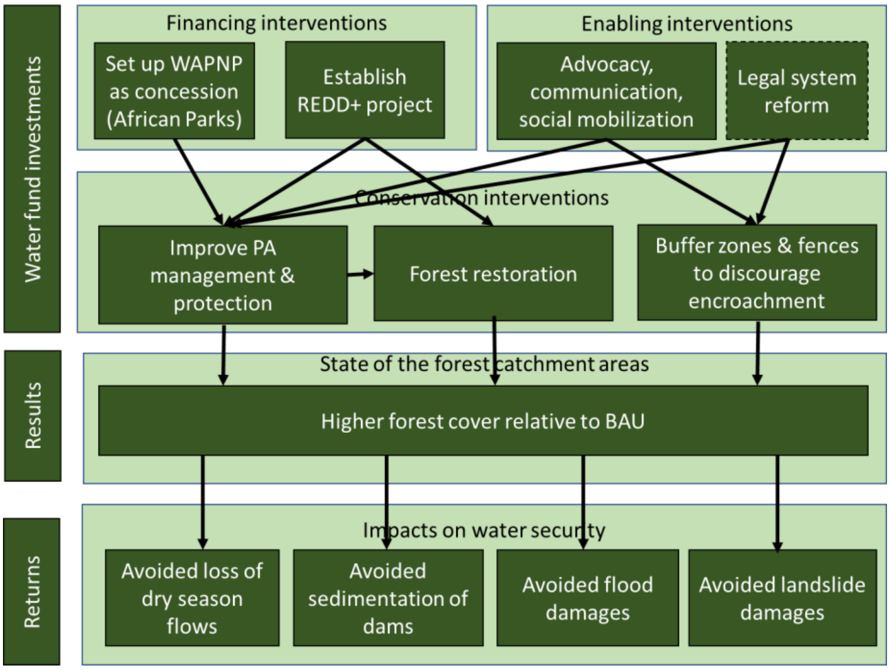

Figure 5.1. Schematic diagram showing the different types of interventions and how they relate to the expected water security benefits.

5.2 Flow regulation

Natural ecosystems slow down and reduce the magnitude of water flows in the wet season, and by facilitating infiltration of rainfall into the ground, contribute to river base flows during the dry season. This reduces the size of reservoirs that are needed to meet water demands, as well as affecting the availability of water to people who draw water directly from streams and rivers for domestic and agricultural use. Recharge, and thus contribution to baseflow, are generally higher in areas under natural vegetation and higher rainfall, although soil characteristics are another moderating factor.

In the Western Area Peninsula, a number of low-income residents rely on unprotected wells as well as rivers and streams for their daily water needs. Even in some areas where access to protected water sources are available, people continue to use water from rivers and streams because of ease of access, lower cost and cultural preference (Harris, Kooy & Jalloh, 2012). However, in the dry season months (December to April) demand for water can exceed supply and residents are forced to find an alternative, which usually involves purchasing water from informal vendors at water stands or from informal vendors selling bottled water or water in plastic sachets.

In this study the flow regulation service was evaluated in terms of water availability in the dry season, measured as the value of avoided costs in purchasing water from vendors at stand posts in months where instream yields fall short of demand. In order to determine this value, the proportion of the population depending on rivers and streams for water supply was extracted from the 2015 Census (SSL, 2017) for the rural and urban population living in the Western Area Peninsula, and linked to the sub-catchments (SWAT watersheds) based on spatial data on populations (www.worldpop.org - School of Geography and Environmental Science, Department of Geography and Geosciences & Departement de Geographie, Universite de Namur) and Center for International Earth Science Information Network (CIESIN), 2018). Using the Basic Human Needs allowance of 75 litres per person per day as stipulated by the World Health Organization, we estimated the monthly water demands by these households within each sub-catchment. These were then compared with the modelled monthly flows in each sub-catchment for the BAU and Conservation scenarios. Assuming a yield ratio of 0.2, we determined the number of months in which demands were not met in each sub-catchment under the BAU scenario, and then computed the extent to which the Conservation scenario mitigated these shortages. These differences were valued at the cost of purchasing water from informal water vendors at stand posts, which is the most common reality for areas where water shortages occur. The costs were taken from Harris, Kooy & Jalloh (2012).

Dry season flows were about 11 000 m^3 more under the Conservation scenario than under the BAU scenario, amounting to an estimated annual cost saving to poor households of **US$436 941** per year. The benefits were highest in the urban sub-catchments in the north of the peninsula where demand was estimated to be highest. In the rural areas of the peninsula the overall number of households was lower and therefore, even though reliance on rivers and streams was higher, total demand was low, resulting in a minimal impact in the sub-catchments further south of the peninsula.

5.3 Erosion control

Forest cover reduces soil erosion and transport of sediment to downstream habitats. This can occur through both *in situ* retention of soil due to vegetation cover, as well as through the trapping of sediments that have been eroded from elsewhere in the landscape. Forest cover can therefore help to prevent negative impacts of excess sediment loads in watercourses, such as reduced water quality and loss of reservoir storage capacity. The forests of the WAPNP are important for soil erosion control, trapping sediments and preventing them from entering the Guma and Congo water supply reservoirs that are situated within the WAPNP. Furthermore, erosion and sedimentation can increase flood risk, affect the quality of drinking water and increase water treatment and maintenance costs at water treatment works. While soil erosion is a natural process, it is greatly accelerated through deforestation. Trees anchor the soil and protect it from the elements through leaf litter and canopy cover. When deforestation occurs, the land becomes exposed to the elements and the soil is more easily washed away. This increases the risk of landslides, sedimentation of reservoirs, stream bed aggradation (which leads to increased flooding), and aquatic habitat alteration.

Results from the 1D morphological modelling which was used to quantify the rate at which sediments would accumulate in the Guma and Congo reservoirs showed that deforestation under the BAU scenario would have a significant impact on water supply through the reduction in the lifespan of these reservoirs (see Smith, Shugart-Schmidt & Cotugno, 2020). These reservoirs are essential for supplying water to Freetown during the dry season between December and April when only 11-17% of the annual river discharge occurs. Under the BAU scenario it was estimated that the Guma reservoir would be completely filled with sediments within 20 years. Under the Conservation scenario, the lifespan of the dam would be increased to 75 years. Results were similar for the Congo reservoir with full capacity being lost in just 16 years under the BAU but 51 years under the Conservation scenario. The amount of sediment entering the Guma reservoir was reduced by 76% per year under the Conservation scenario compared to the BAU and by 67% for the Congo reservoir. Under the Conservation scenario a total of 8 812 tonnes of sediment was abated each year relative to the BAU (Table 5.1).

Table 5.1. Annual sediment loads into the Guma and Congo reservoirs and the total tonnes of sediment abated each year under the Conservation scenario relative to the BAU.

Scenario	Annual sediment (t/y) Guma reservoir	Annual sediment (t/y) Congo reservoir	Total annual sediment into water supply dams (t/y)	Tonnes abated (t/y)
BAU	7 908.0	4 190.3	12 098.3	
Conservation Sc	1 889.6	1 396.9	3 286.5	8 812.8

Sediment outputs from the SWAT model were used to estimate the impact of the Conservation scenario on sediment yields across all catchments of the Water Fund Analysis Area (i.e. in terms of the amount of sediment abated and the impact on downstream aquatic environments). Deforestation will result in increased silt loads and increased silt deposition into the estuaries of the Western Area Peninsula. This increased deposition may cause further increases in flood levels and consequently increased inundation of buildings. Loss of natural vegetation under the BAU scenario would increase sediment yields by more than 50% compared to the Conservation scenario (0.02-5.91 t/ha/y versus 0.01-2.82 t/ha/y; Table 5.2). When compared to the BAU, the forests of the WAPNP retained 71 655 tonnes more of sediment per year on average under the Conservation scenario.

Table 5.2. The min, max and mean sediment yield values (t/ha/y) for the Conservation scenario, the tonnes of sediment exported per year and the total amount of sediment abated relative to the BAU (t/y).

Scenario	Sediment yield			Tonnes of sediment exported (t/y)	Tonnes of sediment abated relative to BAU (t/y)
	Min (t/ha/y)	Max (t/ha/y)	Mean (t/ha/y)		
BAU	0.02	29.39	5.91	151 617	
Conservation Sc	0.01	18.04	2.82	65 704	71 655

The results highlight the function of the forests in retaining sediments, preventing thousands of tonnes of sediment entering water supply reservoirs and downstream aquatic habitats each year. Without the forests providing erosion control, alternative conventional infrastructure would need to be implemented to prevent the loss of storage capacity and sedimentation of downstream aquatic environments. The costs of the alternative conventional infrastructure represents either the replacement cost or the damage costs avoided and is used to value the erosion control service provided by the forests of the WAPNP.

The erosion control service was quantified as the amount of soil loss avoided per year in the catchments of the Guma and Congo reservoirs and the amount of soil loss avoided per year to downstream aquatic environments. The avoided sedimentation of the two reservoirs was valued using an avoided damage cost of dredging which included the costs of mechanical dredging and the cost of removing dredge spoil off site. Dredging was costed at US$18 per m^3 and load and haul of the sediment offsite using trucks was costed at US$5 per m^3 per km. A haul distance of 10 km was assumed, and it was assumed that there would be no need to pay for disposal (it would be used for fill). The establishment cost for a dredger was estimated to be in the order of approximately $120 000 and it was assumed that this would need to be replaced every 20 years. The avoided sedimentation of downstream rivers and estuaries was assumed to be fully demanded, and was valued using a replacement cost, being the construction and maintenance of sediment storage basins where the construction of sediment basins were costed at US$2.60 per m^3 and maintenance activities in the form of excavation of sediments using bulldozers, front-end loaders and trucks was costed at US$3.70 per m^3 (all in US$ 2020; Coviello *et al.*, 2015; Mekonnen *et al.*, 2015).

Based on this cost information and using the results from the 1D model of the difference in imposed annual sediment into the Guma and Congo reservoirs between the BAU and Conservation scenario (see Table 5.1), dredging damage costs were estimated to be US$311 000 per year under the Conservation scenario for the Congo Dam and US$531 500 for Guma Dam. Based on the extent of restoration activities within the catchments that feed the two reservoirs, the return on investment would be about **111 tonnes/US$1000**. This is in about ten times higher than if the problem were solved by dredging (**10 tonnes/US$1000)**.

Looking at the downstream benefits of erosion control, if sediment was not being retained by the forests of the WAPNP, the cost of having to construct and maintain check dams to capture all this additional sediment from entering downstream aquatic habitats (see Table 5.2) and excavating and removing this amount of sediment off-site during the dry season using bulldozers, frontend loaders and trucks would cost as much as US$395 643 per year under the Conservation scenario.

5.4 Flood attenuation

The combination of weather-related (e.g. rainfall intensity, extent and duration) and geophysical (e.g. catchment size, geomorphology, soil and land use) characteristics are the main factors that influence flooding (Kareiva *et al.*, 2011). Natural systems such as wetlands or ecosystems with deep permeable soils such as forests can regulate flows through the landscape by slowing flows by means of storage and vegetative resistance and facilitating infiltration into soils as well as improving water quality. In this way these systems ameliorate the potential impacts of flood events by reducing the flood peaks and lengthening the flood period at a lower level, reducing bank and streambed erosion (Vellidis *et al.*, 2003), as well as reducing the risk of damage caused by flooding of downstream areas. The key factors influencing storm peak mitigation are canopy interception, soil infiltration, soil water storage and location.

Ecosystems, such as wetlands, floodplains and forests, affect the water balance within a river catchment through interception, evaporation and infiltration (Nedkov & Burkhard, 2012). Interception depends on the structure of the land and vegetation above ground (i.e. land cover) and infiltration is strongly influenced by soil properties (Brauman *et al.*, 2007; Nedkov & Burkhard, 2012). Surface runoff, which is the main factor for flood formation, is also strongly influenced by other abiotic factors such as topography. Hydrologic ecosystem services can have preventive or mitigating functions (Nedkov & Burkhard, 2012). Certain land cover, such as forests, are able to redirect or absorb incoming water and rainfall ultimately reducing surface runoff and the amount of water entering river systems. Other ecosystems, such as floodplains and wetlands, provide storm peak mitigation services (Nedkov & Burkhard, 2012). These ecosystems provide retention space for any excess water, thereby slowing flows and reducing the impact and power of the flood. Therefore, the conversion of forests and wetlands into agricultural or developed land increases the amount of hardened surface thereby increasing the volume of runoff and flooding associated with storm events (Kareiva *et al.*, 2011). This tends to be valid for small return period storm events as vegetation captures water as it flows through the landscape through canopy interception and enhanced infiltration. However, vegetation has **limited ability to mitigate flooding associated with medium to large return period storm events** because enhanced soil infiltration only captures a small fraction of precipitation for such storm events (Kareiva *et al.*, 2011). This is particularly the case in areas with a strongly monsoonal climate, where storm events involve very high rainfall, as is the case in Sierra Leone. In other words, the service may be more difficult to detect under these circumstances.

Hydrological and hydraulic models can be used to predict the magnitude of particular floods and to quantify the link between changes in land use and land cover, and flood risk (Kareiva *et al.*, 2011). Using this approach, the severity of flooding in terms of water volumes and flow rates, and corresponding damages from the storm event can be estimated. The models provide the opportunity to define the capacities of different land cover types to supply flood regulation in Freetown. High rainfall events and localised flooding in Freetown has in the past caused damage to infrastructure and property as well as resulted in the loss of life. Flooding in Sierra Leone is a regular occurrence (World Bank, 2017, 2018). Flooding is the most common type of natural disaster in the country, occurring frequently during the rainy season between the months of May and October. It is reported that of the total number of people affected by disasters in the country over the last 30 years, 90% were from flooding (World Bank, 2018). The worst affected areas include Kroo Bay, Susan's Bay, Granville Brook, and Lumley in the Western Area, as well as Regent, Port Loko and Kambia Districts. Kroo Bay which is a large coastal informal settlement in Freetown has flooded every year since 2008 (World Bank, 2018). With space a limited commodity in Freetown, flooding is exacerbated in many of these areas by the expansion and development into the floodplain areas.

Protecting and restoring the forests alone will not mitigate the flooding impacts in Freetown. While restoration of the forests will play an important role in regulating flows and reducing the impacts downstream in terms of the numbers of buildings and people affected, the impact will only be marginal. This is because of the way in which the city of Freetown has developed and expanded without adequate stormwater infrastructure in place to capture and divert floods.

The flood attenuation service can be valued using the lower of either flood damages avoided or the avoided costs of replacing the natural systems with alternative flood mitigation options. The avoided damage costs are the extra costs that would be incurred in the form of incremental losses from increased flooding if the natural ecosystems were transformed. The replacement cost method involves estimating the costs of infrastructure that would be required to provide the same level of flood mitigation as the natural systems. In the urban context, as more land becomes transformed, most cities tend to respond to the resultant increased flood risk by implementing engineering solutions such as changes to the stormwater infrastructure. However, in Freetown the city has developed rapidly without upgrading stormwater infrastructure. Retrofitting infrastructure under such circumstances would be prohibitively expensive and would not make economic or engineering sense. The most cost-effective way of mitigating these damages would be through moving people and buildings out of the flood path. Therefore, a damages avoided cost approach was used for this analysis.

Flooding causes direct market losses as well as indirect and non-market losses. Direct market losses can be fairly well estimated using observable data, such as costs of rebuilding or infrastructure repair. Non-market losses (such as suffering caused by injury or loss of life) and indirect losses are more difficult to quantify and can be contentious (De Risi *et al.*, 2018). Therefore, this analysis only considers the direct market losses associated with flooding in the form of damage to buildings. The damage costs were estimated using a spatial analysis of the inundation impacts on buildings for each watershed and each storm return period under the BAU scenario and Conservation scenarios. The difference in the number of buildings affected between the BAU and Conservation scenarios represents the flood attenuation service provided by the forests of the WAP. Using the inundation results from the Villanova 2D model (Smith et al. 2020) and the World Bank 'GIS-Compatible Hazard, Exposure and Risk Data' (World Bank, 2018) the number of buildings inundated and the associated rebuild costs (US$) for all buildings were estimated. This was calculated for each watershed and each return period to determine the total damage costs avoided. A summary of the inundation results for all seven watersheds is shown in Table 5.3. The results varied significantly across the watersheds (Figure 5.2) and these are presented separately below.

Table 5.3. A summary of the increase in inundation area, and number of buildings and people affected under the BAU relative to the Conservation scenario for all seven urban watersheds in Freetown.

Storm Return Period	Increase in inundation area (ha)	Increase in number of buildings affected	Increase in number of people affected
2	2.82	95	372
5	3.03	72	245
10	3.43	80	395
25	2.73	68	327
50	2.91	59	301
100	3.01	53	377

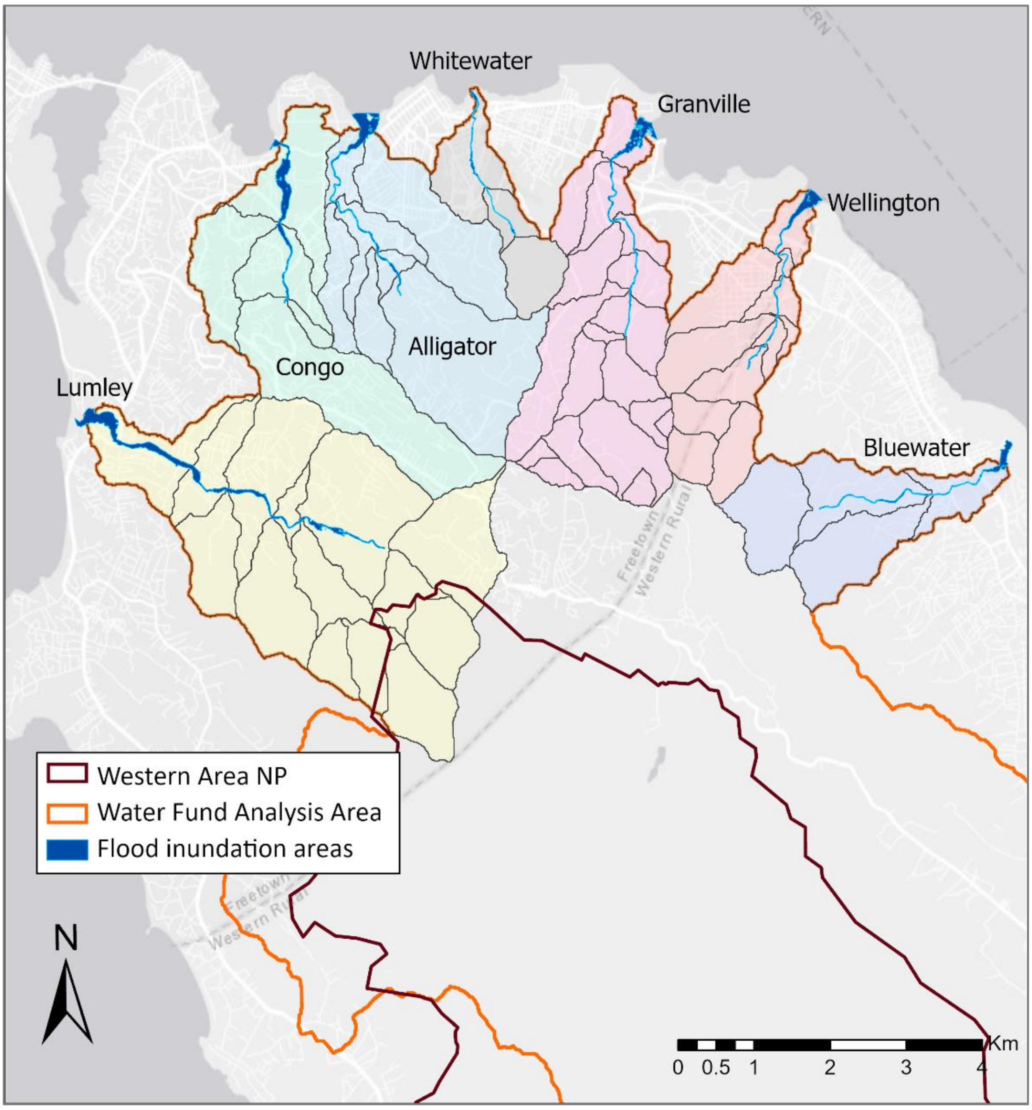

Figure 5.2. The seven urban watersheds in Freetown where flooding is a major problem, that were modelled, and damage costs were estimated as part of this study.

5.4.1 Lumley

In the Lumley watershed both formal and informal buildings were inundated during the different flood return periods. Under each return period the number of formal buildings inundated was higher than the number of informal buildings inundated, resulting in relatively high rebuild costs compared to other watersheds. Surprisingly, the difference in the number of buildings affected between the BAU and Conservation scenario, and total rebuild costs remained stable across the storm events with no difference between the two-year storm event and 100-year storm event. Damage costs avoided were highest under the 10-year storm return period.

5.4.2 Granville

In the Granville watershed formal and informal buildings as well as industrial and educational buildings were inundated across all storm return periods. Under the 100-year storm event more than 300 buildings were inundated under the BAU scenario. This was higher than the total number of buildings affected in the Lumley watershed but lower than the total number of buildings inundated in the Alligator and Congo watersheds. The Granville watershed experienced the second highest expected annual damage costs avoided and the second highest number of buildings affected. This suggests that the interventions (agroforestry and riparian buffers) in this watershed would reduce the expected annual damage costs.

5.4.3 Alligator

Due to the denser population of the Alligator watershed, the total number of buildings inundated exceeded more than 750 under the 100-year storm event. Of these, more than 93% were informal structures. There were also two health care facilities and two educational facilities affected by flooding. While the difference in the expected annual number of buildings inundated between the BAU and Conservation scenarios was highest in this watershed, the expected annual losses were lower than in the Granville and Lumley watersheds, due to the overwhelmingly high number of informal buildings affected which lowered the rebuild costs. The difference in the number of buildings inundated between the BAU and Conservation scenarios was highest under the 2-year, 5-year and 10-year return periods with less of an impact under the higher storm events. This is expected as vegetation has limited ability to mitigate flooding associated with medium to large return period storm events.

5.4.4 Wellington

The number of buildings and people affected by flooding in this watershed was much lower than the other watersheds. A total of 83 buildings were affected by flooding under the 100-year storm event, which is orders of magnitude lower than in the Alligator watershed. The difference between the BAU and Conservation scenarios was also relatively minor with just two buildings expected to be inundated each year. The number of formal buildings inundated was higher than the number of informal buildings, resulting in higher rebuild costs and associated expected annual damage costs avoided.

5.4.5 Bluewater

Similarly, to Wellington, this watershed had a relatively low number of buildings inundated under the various storm events and the difference between the BAU and Conservation scenarios was minimal. The difference in the number of buildings inundated each year between the BAU and Conservation scenarios was expected to be just four in Bluewater and expected annual damage costs avoided were relatively low due to the lower rebuild costs in this watershed.

5.4.6 Whitewater

The total number of buildings affected by flooding in the Whitewater watershed were relatively low compared to some of the other watersheds at just over 100 under the 100-year storm event. Across all of the storm return periods, the difference between the BAU and Conservation scenarios was minimal. The difference in the expected annual number of buildings inundated was just one. More informal buildings were inundated than formal buildings and a government facility was also inundated under all scenarios and all storm return periods.

5.4.7 Congo

More than 400 buildings were estimated to be inundated in the Congo watershed during the 100-year storm event. Of these, 90% were informal buildings. The difference in the number of buildings affected between the BAU and Conservation scenarios was minimal across all storm events and the difference in the expected annual number of buildings flooded was just two. The rebuild costs associated with these informal buildings was very low, with an average rebuild cost of just US$1 276 per building. This resulted in very low expected annual losses in this watershed.

5.4.8 Summary of expected annual losses

The damage costs avoided for each watershed were converted into expected annual losses (EAL) by applying probability of occurrence functions to each storm period. Under the Conservation scenario, expected annual damage costs were estimated to be **US$2.05 million** lower than under the BAU scenario, with the average number of buildings flooded being reduced by74 (Table 5.4). Note that these damage cost estimates are conservative in that they do not include loss of productivity and loss of life that also accompanies flooding events. The expected benefit of the Conservation scenario was greatest in the Lumley, Granville and Alligator watersheds. This is partly an artefact of the hydrological modelling, in that the extent of urbanisation was not increased under the Conservation scenario. Note that there were no conservation interventions in the Alligator water shed.

Table 5.4. Expected annual losses in terms of the number of buildings inundated and the total rebuild costs (US$/y) for each of the seven urban watersheds in Freetown. Note that this represents the difference between the BAU and Conservation scenario, i.e. the damage costs avoided.

Watershed	Difference in the number of buildings inundated	Difference in expected annual losses (US$)
Lumley	8	1 052 040
Granville	16	499 471
Alligator	42	273 779
Wellington	2	110 319
Bluewater	4	76 511
Whitewater	1	31 322
Congo	2	2 441
TOTAL	**74**	**2 045 882**

The results from the 2D hydraulic model of the seven urban watersheds in Freetown highlight the severity of the flooding problem in the city and the relatively limited ability of forests to completely mitigate flooding associated with storm events. While the overall impact of forests on reducing flooding impacts is relatively small, the impact is not negligible and would provide an annual cost saving of US$2.05 million in terms of total damages avoided when compared to the BAU. This results in a return on investment of US$1.65 – for every US$1 invested in restoration activities would result in a US$1.65 cost saving in terms of damage costs avoided.

5.5 Landslide mitigation

Freetown is prone to landslides, triggered by high levels of intense rainfall over short periods of time and exacerbated by human activities such as encroachment which has caused rapid and extensive deforestation (World Bank, 2018). Most of the landslide hazard is concentrated in the steep hills around Freetown in the areas of Regent, Goderich and Tacugama (World Bank, 2017). The rapid increase in the number of houses built on deforested slopes upstream of natural drainage channels in Freetown over the last decade has increased landslide and flooding risk across the city. Deforestation increases landslide hazard. Indeed, the high rate of deforestation in and around the WAPNP has been linked to recent environmental disasters and natural hazards such as erosion, landslides and mudflows, rock falls and flooding (World Bank, 2017). The most recent major landslide in August 2017 caused extensive damage and loss of life. A total of 1 141 people died in the event and more than 3 000 people lost their homes (World Bank, 2017). A rapid damage and loss assessment carried out by the World Bank estimated the total damages to be in the order of US$31.65 million (World Bank, 2017).

While the impact of deforestation on landslides was not modelled during this study, a recent landslide risk and hazard assessment by The World Bank in Freetown provides estimates of the average annualised landslide risk to Freetown and associated average annual losses (see World Bank, 2018). These data (Table 5.5) highlight the current situation and potential future impacts along a BAU path. While reforestation and strict protection of the forests of the WAPNP are unlikely to prevent all future landslides, such interventions are likely to decrease future risk in certain areas and contribute to stabilising soils and infiltrating rainfall. This is particularly important given the exacerbating effects of climate change.

Using the mean estimate, the average annual losses are estimated to be in the order of US$360 000, with an average number fatalities of 11 people and 140 people affected. This is a substantial annual cost that could reach up to US$710 000 per year (Table 5.5). These values are also likely to be an underestimate as they do not consider the health, education, and social protection costs or the water and sanitation costs of such an event.

Table 5.5. The estimated average annual losses associated with landslide risk in Freetown. Source: Quantitative landslide risk assessment conducted by World Bank (2018).

Risk metric	Lower estimate	Mean estimate	Upper estimate
Number of fatalities	1	11	20
Number persons affected	25	140	255
Number of buildings affected	3	16	29
Building losses (US$)	9 000	355 000	701 000
Road length affected (km)	0.03	0.15	0.27
Road losses (US$)	<1 000	5 000	9 000

6 Co-benefits of conservation scenarios

6.1 Nature-based tourism

In Sierra Leone, tourism is estimated to account for 4% of the total economy contributing US$156.8 million in 2019 (WTTC, 2020). Tourism in Sierra Leone is largely underdeveloped and remains off the radar for most tourists. However, the development of the tourism industry is a government priority, and international tourist arrivals have been increasing over the last decade (Figure 6.1). Besides the drastic dip in arrivals in 2015 due to the Ebola Virus Disease, and the recent impact of COVID-19 on global tourism, international arrivals have been on the increase since 2010 in Sierra Leone. Indeed, according to the United Nations World Tourism Organisation (UNWTO) Sierra Leone was listed as one of the fastest-growing tourism countries in the world in 2016. It is therefore unsurprising that the tourism industry has become the most dynamic and fastest growing industry in the country.

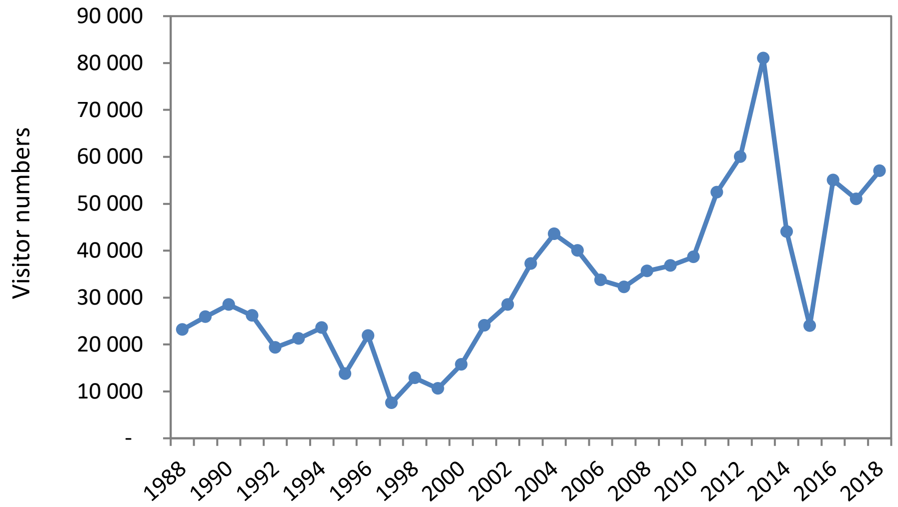

Figure 6.1. International visitors to Sierra Leone 1988-2018. Source: Statistics Sierra Leone 2012, World Bank Database https://data.worldbank.org/.

Holiday tourists, who account for most of the expenditure on visiting tourism attractions, represent about 22% of tourists to Sierra Leone (Table 6.1, Statistics Sierra Leone, 2011). The total attraction-based tourism value (in terms of direct contribution to GDP) in 2019 for Sierra Leone was estimated to be US$23.3 million. Based on empirical evidence of tourist activity (photo densities, see Box 3) it was estimated that 2.2% of this national value were attributed to the WAPNP (Table 6.2, Figure 6.2). The total nature-based tourism value of the WAPNP was therefore estimated to be US$0.5 million in 2019, with a per hectare value of US$27.

Table 6.1. Typology of tourists to Sierra Leone in 2012. Note that more recent data could not be found. Source: Statistics Sierra Leone (2011).

Purpose of visit	Sierra Leone
Holiday	22%
VFR	18%
Business	35%
Other	25%

Table 6.2. **The estimated total attraction-based tourism value for Sierra Leone in 2019 and estimated nature-based tourism value of the WAPNP. All values in 2019 US$ millions.**

	Tourism direct contribution to GDP	Leisure spend as a proportion of total spend	Total attraction-based tourism value	Tourism value of WAPNP	% of national value
Sierra Leone	US$62.7 m	38%	US$ 23.3 m	US$0.50 m	2.2%

The map of tourism value (Figure 6.2) clearly shows that the protected areas within Sierra Leone currently generate a very small percentage of the overall attraction-based tourism value. There is very little information on the number of visitors to Sierra Leone's National Parks. Without any infrastructure, tourism in the WAPNP is limited to the Tacugama Chimpanzee Sanctuary in the north-eastern corner of the park. The sanctuary was founded in 1995 and cares for over 100 confiscated chimpanzees. The sanctuary is open to tourists and provides accommodation in six small eco-lodges. The value associated with this attraction represents more than 50% of the nature-based tourism value of the National Park.

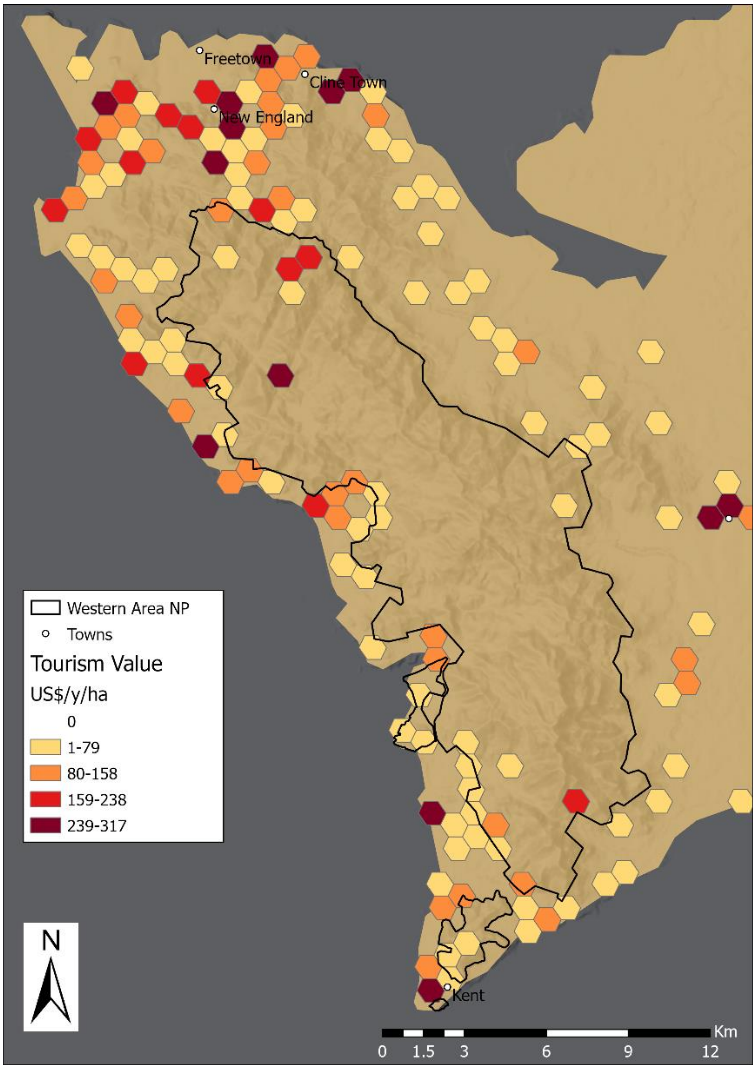

Figure 6.2. Nature-based tourism value (US$/ha/y) for 2019 across the Western Area Peninsula and WAPNP, based on the distribution of geo-referenced photographs uploaded to Flickr (see Box 3).

Sierra Leone, and in particular, the Western Area Peninsula has beautiful beaches and rainforest that is home to a number of endangered primate species such as the Western Chimpanzee and the Colobus and Diana monkeys. Being in close proximity to the capital Freetown, and therefore easily accessible, the WAPNP is well positioned to attract tourists. Within the WAPNP close to 400 bird species and 50 mammal species have been recorded, as well as seven species of primate (Brncic, Amarasekaran & McKenna, 2010). It is estimated that there are about 55 chimpanzees living in the WAPNP. Furthermore, the reserve protects the largest remaining moist closed forest in western Sierra Leone and is the western-most remnant of Upper Guinean forest (Brncic *et al.*, 2010). Given the size of the WAPNP, high-value, low-volume ecotourism would be most appropriate and through careful planning and development could generate significant revenues, much higher than the current US$27 per hectare value.

Under the BAU scenario, without any intervention to protect the forests of the WAPNP and promote ecotourism, it is assumed that tourism will remain limited within the National Park, following current trends of tourism growth. Under the Conservation scenario where interventions are in place to protect the forest and promote ecotourism through private tourism concessions it is assumed that the per hectare value of the WAPNP increases, reaching values by 2050 that are seen in similar forest parks elsewhere in Africa, e.g. Gombe Streams National Park in Tanzania. Additionally, the proximity to Freetown allowing for ease of access could further increase values to be higher than those parks that are more remote. However, given the small size of the WAPNP, the focus should be on generating high-value ecotourism to control numbers and to protect this sensitive ecosystem.

In order to estimate the change in tourism value over time it was assumed that under the BAU tourism would grow at current rates of around 4.5% per year (Figure 6.3). For the Conservation scenario, tourism in the National Park was assumed to grow to reach values seen in other well protected Parks in Africa with similar characteristics.

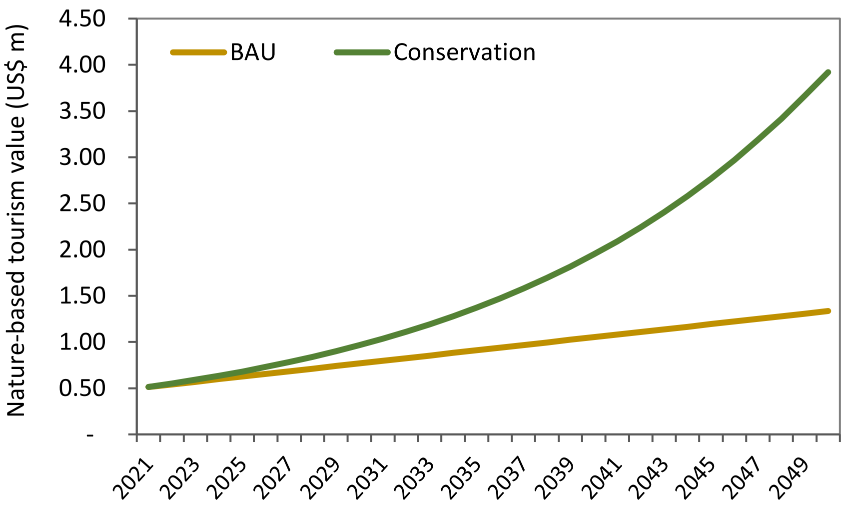

Figure 6.3. Estimated nature-based tourism value (US$ millions) of the WAPNP under the BAU and Conservation scenarios.

Gombe National Park in Tanzania was used as a target value where the nature-based tourism value is estimated to be US$230 per hectare, eight times higher than that of the WAPNP. Much like the WAPNP, Gombe is small in size covering just less than 5000 hectares, has steep forested slopes and is home to around 150 chimpanzees. It is regarded as one of the top places to track chimpanzees in the wild. This small national park is also easily accessible and makes for a good comparison as to what the WAPNP could generate in the future if protected and promoted as a unique ecotourism destination. Using US$230 per hectare as a target value, nature-based tourism associated with the WAPNP grows at a rate of 7% per year under the Conservation scenario (Figure 6.3). In 2050 this would generate a total of US$1.36 million under the BAU and US$3.92 million under the Conservation scenario, a difference of US$2.56 million per year.

Box 3. Approach used in estimating the nature-based tourism value of the Western Area Peninsula National Park.

Tourism value was estimated following the methods of Turpie *et al.* (2017b) who used a combination of national and sub-national tourism data and the density of geotagged photographs uploaded to the internet to map tourism value to ecosystems and other attractions. Tourism direct contribution to GDP was extracted for Sierra Leone from the World Travel and Tourism Council – WTTC; WTTC (2020). The proportion of tourism expenditure attributed to visiting attractions, as opposed to activities such as visiting family and friends, attending conferences and religious events, or receiving medical treatment was then estimated for each category of tourists (holiday, visiting friends and relatives, business and other) based on information collated from tourism statistics reports and information related to tourist spending patterns (Statistics Sierra Leone, 2011). Tourists whose main purpose is either visiting friends or family, or business tend to spend much less of their money on visiting attractions than holiday/leisure tourists. These types of tourists do, however, make up a large proportion of the total tourism spending and so these contributions are not insignificant. Information on the breakdown of visitor activity and expenditure was not available for Sierra Leone, thus assumptions were made on the percentage of spending on visiting tourism attractions by purpose of travel, based on data from South Africa.

The spatial distribution of tourism value was mapped based on the density of geotagged photographs uploaded on the website *flickr.com*. These densities were obtained using the InVEST Recreation Model 3.5.0 (www.naturalcapitalproject.org) which uses an API to get data from the website into a grid specified by the user (in our case a hexagon grid). Densities of geotagged photographs uploaded to platforms such as *flickr.com* provide a means of mapping value to tourism attractions, rather than to the places where tourists spend their money (e.g. at their accommodations), so is more accurate in assigning the tourism value to the actual attractions that caused the expenditure. The model calculates the average annual photo-user-days (PUDs) for each grid cell (1 km x 1 km) across the period 2005-2017. The model used the latitude/longitude data from photographs as well as the photographer's username and photo date to calculate PUDs. One PUD is one unique photographer who took at least one photo in a specific location on a single day.

Empirical evidence supports the use of this method. Wood *et al.* (2013) used the location of geotagged photographs in Flickr to estimate visitation rates at over 800 recreational sites around the world and compared these estimates to empirical data at each site. The study found that using geotagged photographs can indeed serve as a reliable proxy for empirical visitation rates and can provide opportunities for understanding which elements of nature attract people to locations and whether changes in ecosystems will alter visitation rates (Wood *et al.*, 2013). Lee & Tsou (2018) studied geotagged Flickr photos collected from the Grand Canyon area over a 12-month period and found that the frequency of uploaded monthly photos was similar to total tourist numbers counted at the site. The study also used spatiotemporal movement patterns of tourists in conjunction with the uploaded photos to show how this approach can be used for the improvement of national park facility management and regional tourism planning. Barros, Moya-Gómez & Gutiérrez (2019) explored the potential of geotagged data to analyse visitors' behaviour in a national park in Spain. Using geotagged photo data from Flickr and GPS tracks from a web platform called Wikiloc the study determined the spatial distribution of visitors, the points of interest with the most visits, itinerary network, temporal distribution and visitors' country of origin, which was used to improve national park facilities and management.

6.2 Carbon storage

Natural ecosystems make a significant contribution to global climate regulation through the sequestration and storage of carbon. About half of all vegetative biomass comprises carbon. In addition to accumulation in woody biomass, carbon accumulates in soils and peat as a result of the accumulation of leaf litter and partially decayed biomass. Degradation of vegetated habitats releases carbon and contributes to global climate change with impacts on biodiversity, water supply, droughts and floods, agriculture, energy production and human health, whereas restoration or protection of these habitats mitigates or avoids these damages, respectively. The conservation and restoration of natural systems thus helps to reduce the rate at which greenhouse gases accumulate in the atmosphere and the consequent impacts of climate change.

Tropical forests play a critical role in the global carbon cycle (Glenday, 2006; Lewis, 2006). While they only cover about 10% of the earth's surface, they are carbon-dense and highly productive, storing approximately half of all carbon in terrestrial vegetation and processing six times as much carbon as emitted through anthropogenic fossil fuel use each year (Lewis *et al.*, 2009). Therefore, even small changes in the extent and intactness of the forest biome can have significant global impacts. Indeed, it has been estimated that forest loss accounts for 12-17% of global greenhouse gas emissions (Nakakaawa, Vedeld & Aune, 2011).

Based on global datasets derived from satellite data (see FAO & ITPS, 2018; Spawn & Gibbs, 2020, Box 4), it was estimated that approximately 12.6 million tonnes of carbon are stored within the vegetation and soils of the WAPNP (Table 6.3, Figure 6.4). The amount of carbon stored within the forest landscape of the WAPNP ranged from as low as 42.6 tonnes per hectare to as much as 1024.3 tonnes per hectare, with a mean value of 690 tonnes per hectare. These values are comparable to estimates of carbon stocks from Gola National Park in south-eastern Sierra Leone and Singamba natural forest in southern Sierra Leone (Lindsell & Klop, 2013; Brima Mattia & Sesay, 2020).

Outside of the National Park, the carbon storage is significantly lower as forest has been converted to agriculture and other land uses. Areas within the WAPNP that have been illegally converted to agriculture are also noticeable.

Table 6.3. The total amount of carbon stored within the WAPNP and summary statistics (tonnes carbon per hectare)

	Total stock of carbon (tonnes)	Min	Max	Mean
WAPNP	12 645 634	42.6	1024.3	690

It has been estimated that a tonne of carbon released into the atmosphere will cause global damages in the order of US$417 (net present value over 80 years, Ricke *et al.*, 2018, Box 4), of which Sierra Leone's share is US$0.09 per tonne. The total global damage costs avoided by retaining the total stock of biomass carbon is substantial at just over US$1.1 billion per year (Table 6.4). The avoided damage cost to Sierra Leone is estimated to be just under US$0.25 million per year.

Table 6.4. The total global damage costs avoided by retaining the total stock of biomass carbon and the avoided damage cost to Sierra Leone (US$/y)

	Rest of the world	Sierra Leone
Carbon storage value (damage costs avoided, US$/y)	1 117 813 100	241 255

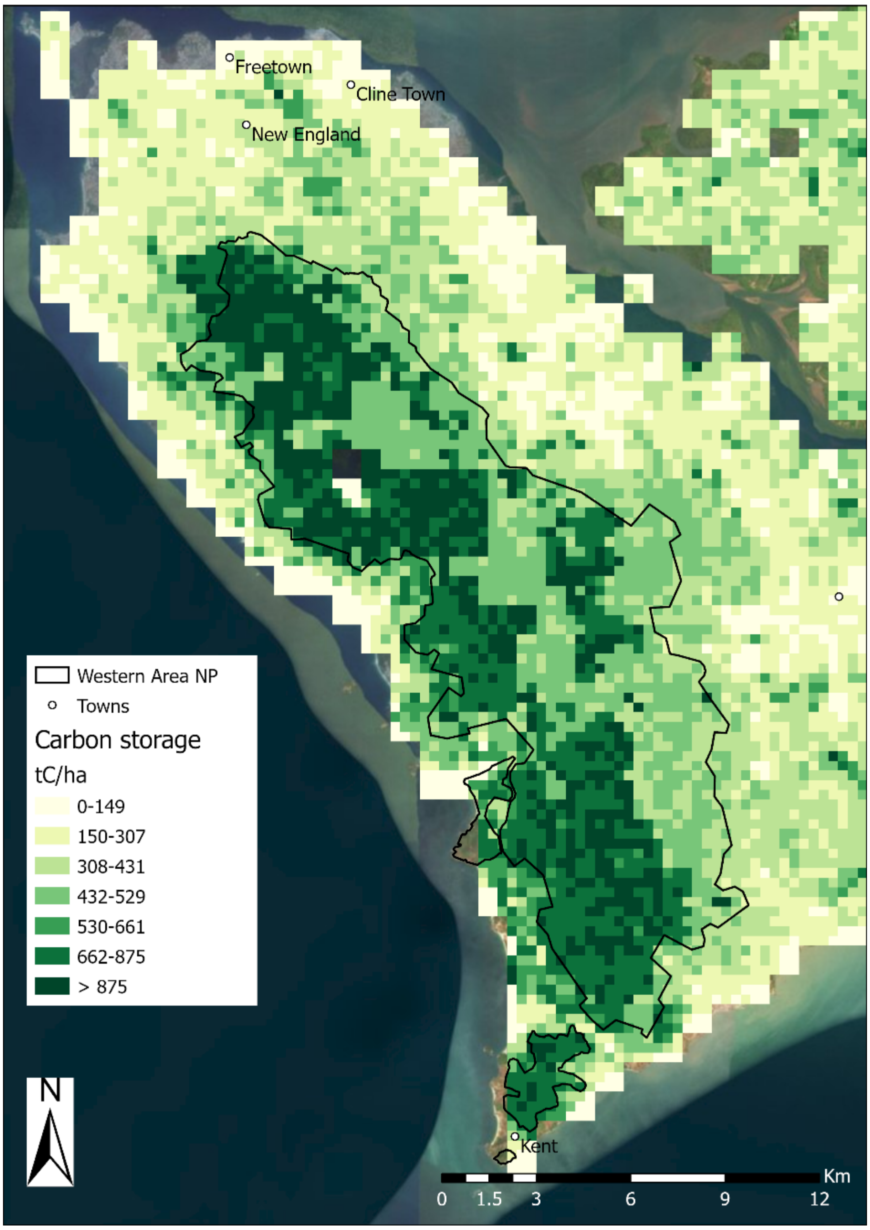

Figure 6.4. Total carbon storage (tonnes/ha) across the Western Area Peninsula of Sierra Leone and the WAPNP.

Following a 'do nothing' approach under the BAU results in an estimated loss of 5115 hectares of forest from the WAPNP. Using the mean estimate of 690 tonnes of carbon per hectare it is estimated that a total of 3.53 million tonnes of carbon could be lost through encroachment and degradation following existing trends in development and urbanisation (Table 6.5). Strict protection of the forest in the national park would result in the prevention of losses under the BAU as well as any gains in carbon storage through the implementation of restoration interventions under the Conservation scenario. A total of 12 556 hectares of forest can be restored by 2050 under the Conservation scenario using various levels of active and passive restoration interventions. The loss in forest under the BAU would result in global losses of US$312 million per year and a national loss of some US$ 70 000 per year. Conservation of the WAPNP would result in a gain of over 8.6 million tonnes of carbon, avoiding global damage costs of US$765 million and some US$170 000 to Sierra Leone.

Table 6.5. The extent of losses and gains in carbon stored in the forest of the WAPNP and the global and national damage costs avoided by retaining the stock of biomass carbon under the BAU and the Conservation scenario.

	Loss in forest	Gain in forest
	BAU	**Conservation Sc**
Area (ha)	- 5 115	12 556
Stock of carbon (tonnes)	- 3 527 426	8 658 918
Carbon storage global (US$ m/y)	311.8	765.4
Carbon storage national (US$ m/y)	0.07	0.17

Box 4. Approach used in estimating the carbon storage value of the forests of the Western Area Peninsula National Park

Carbon storage was valued using the most up to date global datasets available on carbon stocks, including above- and below-ground biomass and soil carbon (see FAO & ITPS, 2018; Spawn & Gibbs, 2020). The carbon retention value of these stocks was valued in terms of the avoided losses of economic output by Sierra Leone in the WAPNP as well as the rest of the world, using recent published estimates of the global and disaggregated country-specific damage effects of climate change (see Ricke *et al.*, 2018). These damages are expressed as US dollars per tonne of CO_2 emissions and for Sierra Leone are estimated to be US$0.09 per tonne of CO_2. Thus, carbon stocks were first converted to the equivalent quantity of CO_2 using molecular weight of CO_2 divided by molecular weight of carbon (~3.67).

The social cost of carbon is estimated as a net present value of climate change impacts over the next 80 years of one additional ton of carbon emitted into the atmosphere today. To generate an annual value, country-specific discount rates were used (3.99% for Sierra Leone, see Addicott, Fenichel & Kotchen, 2020) and a time frame of 80 years (see Ricke *et al.*, 2018).

6.3 Biodiversity

The strict protection and restoration of the WAPNP would lead to an improvement in its flora and fauna, which is something that many members of society, even beyond Sierra Leone, would value. These kinds of values, referred to in the literature as non-use or existence values, are intangible and difficult to quantify, even with best-practice stated preference methods. The WAPNP is very important from a conservation perspective, e.g. as a habitat for rare and endangered species such as the Western Chimpanzee. While this study has not attempted to estimate existence value, this benefit is likely to be very significant and should be acknowledged.

7 Cost-benefit analysis

The Conservation scenario was evaluated using a cost-benefit analysis to quantify the net present value and overall return on investment (ROI, net welfare gains per US$ invested). Cost-benefit analysis is a conceptual framework and tool used to evaluate the viability and desirability of projects or policies based on their costs and benefits over time. It involves the adjustment of future values to their present value equivalent by discounting at a rate which reflects the potential rate of return on alternative investments or the rate of time preference. For a project to be considered viable, the net present value (NPV) must be positive.

Discounting places greater weight on values occurring closer to the present, which means that the future benefits of restoration projects will be down-weighted compared with the upfront investment costs, and have to be substantial in order for a project to be viewed positively. In this analysis most of the intervention costs are upfront capital costs, with some ongoing monitoring and/or maintenance costs. None of the benefits are immediate and the analysis involved estimating the time taken for the conservation interventions to generate meaningful impacts. For example, the benefits of active forest restoration started only in year seven and tourism benefits started in year two rising gradually to reach the target value in 2050.

The quantitative nature of cost-benefit analysis does not necessarily indicate certainty, however. Accurately estimating and forecasting all the costs and benefits is generally challenging. Studies are limited by availability of data and resources, as well as uncertainty in the consideration of changes in factors such as land use, climate, household incomes and rates of urbanisation, for example. It is therefore important to incorporate some form of sensitivity analysis so as to adequately assess the reliability of the estimates.

For this analysis the social rate of discount that takes future generations into account was used (3.99% taken from Addicott *et al.*, 2020) over a time period of 30 years (2021-2050). This was further tested under varying assumptions of costs, benefits and discount rate. The costs and benefits of certain interventions were varied under a range of assumptions to get a better understanding of the viability of the Conservation scenario. This included an exploratory analysis of the impact of less conservative assumptions, such as removing private concessions from the WAPNP. Furthermore, a NPV sensitivity analysis was undertaken using discount rates of 6% and 9%. In this study we compare the Conservation scenario to the 'do nothing' BAU scenario. This is achieved by dividing the difference in benefits of the Conservation scenario versus the BAU scenario by the costs of restoration interventions in achieving the conservation outcomes. This produces a benefit-cost ratio (BCR) or return on investment (ROI), which suggests how many units of benefit each unit of cost brings.

The estimates derived in this study suggest that the Conservation scenario is viable (Table 7.1). The net present value over 30 years was estimated to be US$34.76 million, with a ROI of 2.7. In other words, a US$1 investment by the Water Fund will generate almost US$3 of benefits to stakeholders. The results presented here include the avoided national costs in terms of carbon storage and not the avoided global costs which are orders of magnitude greater. Including the global cost savings in the cost-benefit analysis would result in a net present value in the order of US$13 billion.

Table 7.1. Present value of the costs of interventions and value of ecosystem service benefits for the Conservation scenario (2020 US$ millions, 3.99% discount rate, 30 years).

	Present value (US$ millions)
Costs	**Conservation Scenario**
Improved management of WAPNP	2.94
Active planting (restoration) in WAPNP	5.12
Assisted natural forest regeneration in WAPNP	3.72
Passive forest regeneration in WAPNP	6.17
Agroforestry PES	0.29
Fencing	1.54
Riparian buffer zones	0.17
Total present value of costs	**19.96**
Benefits	
Erosion control	12.30
Flood attenuation	24.69
Flow regulation	5.27
Carbon retention and gains relative to BAU (savings to Sierra Leone)	2.81
Nature-based tourism	9.50
Agroforestry gains from tree introductions	0.15
Total present value of benefits	**54.72**
Net Present Value	**34.76**
ROI	**2.7**

The results from the sensitivity analysis strongly suggest that restoration interventions in and around the WAPNP can be justified in economic terms when enabling conditions are in place to ensure their success (Table 7.2). When the assumption around private partnerships is removed, nature-based tourism does not grow at increasing rates within the WAPNP, then we see that the NPV declines to US$25.24 million with an ROI of 2.3. Varying the timing of the forest restoration benefits to only come online three years later gives a similar result. A 15% increase in the implementation and follow-costs of the conservation interventions results in an NPV of US$31.76 million and an ROI of 2.4. Extending the follow-up costs of forest restoration by a further five years had similar results as increasing costs by 15%. Increasing costs and decreasing the benefits by 15% also did not result in a negative net benefit, with the ROI dropping to 2.0. When the discount rate used was increased to 6% the NPV dropped to US$21.94 million with a ROI of 2.3. If enforcement is not strengthened and there is poor advocacy, communication and social mobilisation (as under the BAU), then the results show a negative NPV and a ROI of less than one due to the failure of ensuring adequate protection of the forests.

These results show that while the net benefits remain positive under varying assumptions, the overall viability of the Water Fund is sensitive to changes in the timing of benefits as well as in terms of the costs of interventions. Furthermore, the success of the Water Fund is largely dependent on enabling interventions that require improvement and strengthening at national and sub-national levels to ensbure community participation and buy-in as well as compliance of environmental laws. Without strengthened enforcement, it is likely that a BAU approach will continue into the future. Realistically, there is a high risk of failure with the supporting interventions within the context of the study area, therefore it will be important to invest in the development of a public-private partnership type arrangement for the WAPNP, as well as in REDD+ to ensure the success of the project.

Table 7.2. Sensitivity analysis under varying assumptions of conservation intervention, timing of benefits, and discount rate (2020 US$ millions, 3.99% discount rate, 30 years).

	Present value & ROI after change (US$ millions)
Without a public-private partnership for park management	
Total present value of costs	19.83
Total present value of benefits	45.07
Net Present Value	**25.24**
ROI	**2.3**
Varying the timing of restoration benefits to be 3 years later	
Total present value of costs	19.83
Total present value of benefits	46.48
Net Present Value	26.65
ROI	**2.3**
15% increase in implementation & follow-up costs	
Total present value of costs	22.81
Total present value of benefits	54.72
Net Present Value	31.91
ROI	**2.4**
Follow-up costs (monitoring and maintenance) extended by 5 years	
Total present value of costs	22.49
Total present value of benefits	54.72
Net Present Value	32.23
ROI	**2.4**
15% increase in costs & 15% decrease in benefits	
Total present value of costs	22.81
Total present value of benefits	46.46
Net Present Value	23.65
ROI	**2.0**
Increasing the discount rate to 6%	
Total present value of costs	17.49
Total present value of benefits	39.44
Net Present Value	**21.95**
ROI	**2.3**
Without enabling interventions in place	
Total present value of costs	19.83
Total present value of benefits	9.91
Net Present Value	-9.92
ROI	**0.5**

8 Conclusions

Even though we were not able to quantify all the potential benefits, the results from the cost-benefit analysis demonstrate a clear economic basis for the establishment of the Western Area Peninsula Water Fund. Overall, a US$20 million investment in restoration interventions under the Conservation scenario is expected to return at least US$55 million in economic benefits over the 30-year timeframe. In other words, every US$1 invested by the Water Fund is expected to generate at least US$2.70 of benefits to stakeholders. Furthermore, catchment restoration is significantly more cost-effective than other conventional interventions. In addition to security in water supply and mitigation of flooding and landslide risk, restoration of the WAPNP forests brings wider benefits in terms of nature-based tourism, climate change resilience, job creation, opportunities for women and most importantly, avoiding the irreversible loss of the unique and valuable biodiversity of the Upper Guinean forest. Sensitivity analysis shows that even under lower benefit and higher costs streams, as well as varying timing and discount rates, economic viability can still be maintained. However, this requires the assurance of adequate enabling conditions, which when removed, result in a negative NPV and BAU trajectory.

The following key results demonstrate the importance of protecting and restoring the forests of the WAPNP and clearly demonstrate the feasibility of establishing the Water Fund. Compared to a business-as-usual scenario:

- About 11 000 m^3 more water would be available to households during the dry season months with an annual cost saving to poor households of US$436 941 per year;
- The amount of sediments entering the rivers of the Western Area Peninsula would be halved, and the lifetime of Guma and Congo reservoirs will be 55 and 35 years longer, respectively;
- Average annual flood damages across the seven urban watersheds would be reduced by US$2.05 million, and the risks of landslides would likely be reduced;
- Gains in nature-based tourism value of the WAPNP could amount to US$3.92 million per annum;
- Carbon stored in the WAP would be 8.6 million tonnes higher, avoiding annual climate change damages of US$170 000 to Sierra Leone and of US$765 million at a global level;
- The more intensive management of the WAPNP, growth in high-end tourism and agroforestry interventions could bring significant employment and livelihood benefits to households living in the WAP.

Enabling interventions are critical for the success of the Water Fund. This will include clear communication on the need for and long-term benefits of some of the necessary strict protection measures in order to get buy-in from all stakeholders

9 References

Addicott, E.T., Fenichel, E.P. & Kotchen, M.J. (2020). Even the Representative Agent Must Die: Using Demographics to Inform Long-Term Social Discount Rates. *J. Assoc. Environ. Resour. Econ.* **7**, 379–415.

Agrawal, A., Wollenberg, E. & Persha, L. (2014). Governing agriculture-forest landscapes to achieve climate change mitigation. *Glob. Environ. Chang.* **29**, 270–280.

Ajayi, O.C., Akinnifesi, F.K., Sileshi, G. & Kanjipite, W. (2009). Labour inputs and financial profitability of conventional and agroforestry-based soil fertility management practices in Zambia. *Agrekon* **48**, 276–292.

Alavalapati, J.R.R. & Mercer, D.E. (2005). *Valuing Agroforestry Systems: Methods and Applications*. *Valuing Agrofor. Syst.* Dordrecht: Kluwer Academic Publishers.

Andam, K.S., Ferraro, P.J., Pfaff, A., Sanchez-Azofeifa, G.A. & Robalino, J.A. (2008). Measuring the effectiveness of protected area networks in reducing deforestation. *Proc. Natl. Acad. Sci. U. S. A.* **105**, 16089–16094.

Atsri, K.H., Abotsi, K.E., Kokou, K., Dendi, D., Segniagbeto, G.H., Fa, J.E. & Luiselli, L. (2019). Ecological challenges for the buffer zone management of a West African National Park. *J. Environ. Plan. Manag.* **63**, 689–709.

Baker, T. & Srinivasan, R. (2020). SWAT (Soil and Water Assessment Tool) simulation of forest interventions on stream discharge and sediment yield in the Western Area Peninsula , Sierra Leone.

Barros, C., Moya-Gómez, B. & Gutiérrez, J. (2019). Using geotagged photographs and GPS tracks from social networks to analyse visitor behaviour in national parks. *Curr. Issues Tour.* **23**, 1291–1310.

Bayrak, M.M. & Marafa, L.M. (2016). Ten years of REDD+: A critical review of the impact of REDD+ on forest-dependent communities. *Sustain.* **8**, 1–22.

Bell, R.H.V. & Clarke, J.E. (1984). Funding and financial control. In *Conservation and Wildlife Management in Africa*: 545–555. Bell, R. & McShane-Caluzi, E. (Eds.). U.S. Peace Corps, Washington, DC.

Benjamin, E.O. & Sauer, J. (2018). The cost effectiveness of payments for ecosystem services—Smallholders and agroforestry in Africa. *Land use policy* **71**, 293–302.

Blom, A. (2004). An estimate of the costs of an effective system of protected areas in the Niger Delta - Congo Basin Forest Region. *Biodivers. Conserv.* **13**, 2661–2678.

Boahene, K. (1998). The challenge of deforestation in tropical Africa: reflections on its principal causes, consequences and solutions. *L. Degrad. Dev.* **9**, 247–258.

Brancalion, P.H.S., Meli, P., Tymus, J.R.C., Lenti, F.E.B., M. Benini, R., Silva, A.P.M., Isernhagen, I. &

Holl, K.D. (2019). What makes ecosystem restoration expensive? A systematic cost assessment of projects in Brazil. *Biol. Conserv.* **240**.

Brauman, K.A., Daily, G.C., Duarte, T.K. & Mooney, H.A. (2007). The nature and value of ecosystem services: an overview highlighting hydrological services. *Annu. Rev. Environ. Resour.* **32**, 67–98.

Brima Mattia, S. & Sesay, S. (2020). Ground Forest Inventory and Assessment of Carbon Stocks in Sierra Leone, West Africa. *Nat. Resour. Manag. Biol. Sci. [Working Title]*.

Brncic, T.M., Amarasekaran, B. & McKenna, A. (2010). *Sierra Leone National Chimpanzee Census*. Freetown, Sierra Leone.

Bruner, A.G., Gullison, R.E., Rice, R.E. & Da Fonseca, G.A.B. (2001). Effectiveness of parks in protecting tropical biodiversity. *Science (80-.).* **291**, 125–128.

Busch, J. & Ferretti-Gallon, K. (2017). What drives deforestation and what stops it? A meta-analysis. *Rev. Environ. Econ. Policy* **11**, 3–23.

Cedrez, C.B., Chamberlin, J., Guo, Z. & Hijmans, R.J. (2020). Spatial variation in fertilizer prices in Sub-Saharan Africa. *PLoS One* **15**, 1–20.

Chazdon, R.L. & Guariguata, M.R. (2016). Natural regeneration as a tool for large-scale forest restoration in the tropics: prospects and challenges. *Biotropica* **48**, 716–730.

Chazdon, R.L. & Uriarte, M. (2016). Natural regeneration in the context of large-scale forest and landscape restoration in the tropics. *Biotropica* **48**, 709–715.

Coviello, V., Vezza, P., Angeluccetti, I. & Grimaldi, S. (2015). *Reducing the impact of soil erosion and reservoir siltation on agricultural production and water availability : the case study of the Laaba catchment (Burkina Faso)*. *Case Stud. Dev. Glob. responsible Eng.* Barcelona.

Crouzeilles, R., Beyer, H.L., Monteiro, L.M., Feltran-Barbieri, R., Pessôa, A.C.M., Barros, F.S.M., Lindenmayer, D.B., Lino, E.D.S.M., Grelle, C.E.V., Chazdon, R.L., Matsumoto, M., Rosa, M., Latawiec, A.E. & Strassburg, B.B.N. (2020). Achieving cost-effective landscape-scale forest restoration through targeted natural regeneration. *Conserv. Lett.* **13**, 1–9.

Crouzeilles, R., Ferreira, M.S., Chazdon, R.L., Lindenmayer, D.B., Sansevero, J.B.B., Monteiro, L., Iribarrem, A., Latawiec, A.E. & Strassburg, B.B.N. (2017). Ecological restoration success is higher for natural regeneration than for active restoration in tropical forests. *Sci. Adv.* **3**, 1–8.

CRS. (2018). *A Western Area Peninsula Water Fund*. Catholic Relief Services, Freetown, Sierra Leone.

Current, D., Lutz, E. & Scherr, S.J. (1995). The Costs and Benefits of Openness. *World Bank Res. Obs.* **10**, 151–180.

Defries, R.S., Rudel, T., Uriarte, M. & Hansen, M. (2010). Deforestation driven by urban population growth and agricultural trade in the twenty-first century. *Nat. Geosci.* **3**, 178–

181.
Dugan, P. (2011). Cost comparison analysis: ANR compared to conventional reforestation. In *Forests beneath the grass: Proceedings of the regional workshop on advancing the application of assisted natural regeneration for effective low-cost forest restoration*: 1–162. Durst, P.B., Sajise, P. & Leslie, R.N. (Eds.). Bangkok.
FAO. (2010). *Global Forest Resources Assessment 2010*. Rome: Food and Agrculture Organisation of the United Nations.
FAO. (2019). *Restoring forest landscapes through assisted natural regeneration (ANR) – A practical manual*. Bangkok: Food and Agrculture Organisation of the United Nations.
FAO & ITPS. (2018). *Global Soil Organic Carbon Map (GSOCmap) Technical Report*. Rome.
Fayiah, M., Dong, S. & Singh, S. (2018a). Status and challenges of wood biomass as the principal energy in Sierra Leone. *Int. J. Biomass Renewables* **7**, 1–11.
Fayiah, M., Otesile, A.A. & Mattia, S.B. (2018b). Review of challenges confronting the implementation and enforcement of environmental policies and regulations in Sierra Leone. *Int. J. Adv. Res.* **6**, 530–541.
Ferraro, P.J., Hanauer, M.M. & Sims, K.R.E. (2011). Conditions associated with protected area success in conservation and poverty reduction. *Proc. Natl. Acad. Sci. U. S. A.* **108**, 13913–13918.
Franzel, S. (2005). Financial analysis of agroforestry practices: Fodder shrubs in Kenya, woodlots in Tanzania, and improved fallows in Zambia. In *Valuing Agroforestry Systems: Methods and Applications*. Alavalapati, J.R.R. & Mercer, D.E. (Eds.). Springer Science + Business Media, Inc.
Geist, H.J. & Lambin, E.F. (2002). Proximate causes and underlying driving forces of tropical deforestation. *Bioscience* **52**, 143–150.
Glenday, J. (2006). Carbon storage and emissions offset potential in an East African tropical rainforest. *For. Ecol. Manage.* **235**, 72–83.
Guma Valley Water Company. (2008). *Water supply improvement plan. As part of the Strategic Water Supply and Sanitation Framework*. Freetown, Sierra Leone.
Hamrick, K. & Gallant, M. (2018). *Voluntary Carbon Markets Insights: 2018 Outlook and First-Quarter Trends*. Forest Trends Ecosystem Marketplace; https://www.forest-trends.org/wp-content/uploads/2018/09/VCM-Q1-Report_Full-Version-2.pdf.
Harris, D., Kooy, M. & Jalloh, G. (2012). The political economy of the urban water-pricing regime in Freetown, Sierra Leone. *London ODI*.
Heino, M., Kummu, M., Makkonen, M., Mulligan, M., Verburg, P.H., Jalava, M. & Räsänen, T.A. (2015). Forest loss in protected areas and intact forest landscapes: A global analysis. *PLoS One* **10**, 1–21.

Hosonuma, N., Herold, M., De Sy, V., De Fries, R.S., Brockhaus, M., Verchot, L., Angelsen, A. & Romijn, E. (2012). An assessment of deforestation and forest degradation drivers in developing countries. *Environ. Res. Lett.* **7**.

James, A.N., Green, M.J.B.B. & Paine, J.R. (1999). *A Global Review of Protected Area Budgets and Staff*. WCMC – World Conservation Press, Cambridge, UK.

Jayachandran, S., Laat, J. De, Lambin, E.F., Stanton, C.Y., Audy, R. & Thomas, N.E. (2017). Cash for carbon: A randomized trial of payments for ecosystem services to reduce deforestation. *Science (80-.).* **357**, 267–273.

Kareiva, P., Tallis, H., Ricketts, T.H., Daily, G.C. & Polasky, S. (2011). *Natural Capital: Theory and practice of mapping ecosystem services.* New York: Oxford University Press Inc.

Kintz, D.B., Young, K.R. & Crews-Meyer, K.A. (2006). Implications of land use/land cover change in the buffer zone of a National Park in the tropical Andes. *Environ. Manage.* **38**, 238–252.

Kiptot, E. & Franzel, S. (2011). *Gender and agroforestry in Africa: are women participating? ICRAF Occas. Pap.* Nairobi: World Agroforestry Centre.

Laurance, W.F., Clements, G.R., Sloan, S., O'Connell, C.S., Mueller, N.D., Goosem, M., Venter, O., Edwards, D.P., Phalan, B., Balmford, A., Van Der Ree, R. & Arrea, I.B. (2014). A global strategy for road building. *Nature* **513**, 229–232.

Lawlor, K., Olander, L., Boyd, W., Niles, J. & Myers Madeira, E. (2009). *Addressing the causes of tropical deforestation: lessons learned and the implications for international forest carbon policy*. Nicholas Institute for Environmental Policy Solutions, Duke University.

Lee, J.Y. & Tsou, M.H. (2018). Mapping spatiotemporal tourist behaviors and hotspots through location-based photo-sharing service (Flickr) data. *Lect. Notes Geoinf. Cartogr.* 315–334.

Lewis, S.L. (2006). Tropical forests and the changing earth system. *Philos. Trans. R. Soc. B Biol. Sci.* **361**, 195–210.

Lewis, S.L., Lopez-Gonzalez, G., Sonké, B., Affum-Baffoe, K., Baker, T.R., Ojo, L.O., Phillips, O.L., Reitsma, J.M., White, L., Comiskey, J.A., Djuikouo K, M.N., Ewango, C.E.N., Feldpausch, T.R., Hamilton, A.C., Gloor, M., Hart, T., Hladik, A., Lloyd, J., Lovett, J.C., Makana, J.R., Malhi, Y., Mbago, F.M., Ndangalasi, H.J., Peacock, J., Peh, K.S.H., Sheil, D., Sunderland, T., Swaine, M.D., Taplin, J., Taylor, D., Thomas, S.C., Votere, R. & Wöll, H. (2009). Increasing carbon storage in intact African tropical forests. *Nature* **457**, 1003–1006.

Lindsell, J.A. & Klop, E. (2013). Spatial and temporal variation of carbon stocks in a lowland tropical forest in West Africa. *For. Ecol. Manage.* **289**, 10–17.

Lindsey, P.A., Masterson, C.A., Beck, A.L. & Romañach, S. (2012). Ecological, Social and Financial Issues Related to Fencing as a Conservation Tool in Africa. In *Fencing for Conservation: Restriction of Evolutionary Potential Or a Riposte to Threatening Processes?*. Somers, M.J. & Hayward, M.W. (Eds.). Springer Science+Business Media.

Lindsey, P.A., Miller, J.R.B., Petracca, L.S., Coad, L., DIckman, A.J., Fitzgerald, K.H., Flyman, M. V., Funston, P.J., Henschel, P., Kasiki, S., Knights, K., Loveridge, A.J., MacDonald, D.W., Mandisodza-Chikerema, R.L., Nazerali, S., Plumptre, A.J., Stevens, R., Van Zyl, H.W. & Hunter, L.T.B. (2018). More than $1 billion needed annually to secure Africa's protected areas with lions. *Proc. Natl. Acad. Sci. U. S. A.* **115**, E10788–E10796.

Mansaray, L.R., Huang, J. & Kamara, A.A. (2016). Mapping deforestation and urban expansion in Freetown, Sierra Leone, from pre- to post-war economic recovery. *Environ. Monit. Assess.* **188**.

Mehring, M. & Stoll-Kleemann, S. (2011). How effective is the buffer zone? linking institutional processes with satellite images from a case study in the Lore Lindu forest biosphere reserve, Indonesia. *Ecol. Soc.* **16**.

Mekonnen, M., Keesstra, S.D., Baartman, J.E., Ritsema, C.J. & Melesse, A.M. (2015). EVALUATING SEDIMENT STORAGE DAMS: STRUCTURAL OFF-SITE SEDIMENT TRAPPING MEASURES IN NORTHWEST ETHIOPIA. *Geogr. Res. Lett.* **41**, 7–22.

Munro, P.G. & van der Horst, G.A. (2012). *The domestic trade in timber and fuelwood products in Sierra Leone: current dynamics and issues*. Energy for Opportunity: Freetown, Sierra Leone.

Nagendra, H., Tucker, C., Carlson, L., Southworth, J., Karmacharya, M. & Karna, B. (2004). Monitoring parks through remote sensing: Studies in Nepal and Honduras. *Environ. Manage.* **34**, 748–760.

Nakakaawa, C.A., Vedeld, P.O. & Aune, J.B. (2011). *Spatial and temporal land use and carbon stock changes in Uganda: Implications for a future REDD strategy*. *Mitig. Adapt. Strateg. Glob. Chang.*

Nedkov, S. & Burkhard, B. (2012). Flood regulating ecosystem services – mapping supply and demand, in the Etropole municipality, Bulgaria. *Ecol. Indic.* **21**, 67–79.

NPAA. (2017). *Status Report on the Western Area Peninsula National Park (WAPNP)*. National Protected Area Authority: Freetown, Sierra Leone.

NWRMA. (2019). *Report on stakeholder assessment of the Western Area water catchment areas*. Freetown, Sierra Leone.

ÖBf. (2012). *REDD + Scoping Study for the Western Area Peninsula Forest Reserve*. Österreichische Bundesforste AG Consulting: Purkersdorf, Austria.

Pekor, A., Miller, J.R.B., Flyman, M. V., Kasiki, S., Kesch, M.K., Miller, S.M., Uiseb, K., van der Merve, V. & Lindsey, P.A. (2019). Fencing Africa's protected areas: Costs, benefits, and management issues. *Biol. Conserv.* **229**, 67–75.

Ricke, K., Drouet, L., Caldeira, K. & Tavoni, M. (2018). Country-level social cost of carbon. *Nat. Clim. Chang.* **8**, 895–900.

De Risi, R., De Paola, F., Turpie, J. & Kroeger, T. (2018). Life Cycle Cost and Return on Investment as complementary decision variables for urban flood risk management in developing countries. *Int. J. Disaster Risk Reduct.* **28**, 88–106.

Robinson, E.J.Z., Albers, H.J. & Busby, G.M. (2013). The impact of buffer zone size and management on illegal extraction, park protection, and enforcement. *Ecol. Econ.* **92**, 96–103.

Roopsind, A., Sohngen, B. & Brandt, J. (2019). Evidence that a national REDD+ program reduces tree cover loss and carbon emissions in a high forest cover, low deforestation country. *Proc. Natl. Acad. Sci. U. S. A.* **116**, 24492–24499.

Schultz, P.W. (2011). Conservation Means Behavior. *Conserv. Biol.* **25**, 1080–1083.

Scullion, J.J., Vogt, K.A., Drahota, B., Winkler-Schor, S. & Lyons, M. (2019). Conserving the Last Great Forests: A Meta-Analysis Review of the Drivers of Intact Forest Loss and the Strategies and Policies to Save Them. *Front. For. Glob. Chang.* **2**, 1–12.

Scullion, J.J., Vogt, K.A., Sienkiewicz, A., Gmur, S.J. & Trujillo, C. (2014). Assessing the influence of land-cover change and conflicting land-use authorizations on ecosystem conversion on the forest frontier of Madre de Dios, Peru. *Biol. Conserv.* **171**, 247–258.

Seymour, F. & Harris, N.L. (2019). Reducing tropical deforestation. *Science (80-.).* **365**, 756–757.

Sims, K.R.E. & Alix-Garcia, J.M. (2017). Parks versus PES: Evaluating direct and incentive-based land conservation in Mexico. *J. Environ. Econ. Manage.* **86**, 8–28.

Smith, V. & Cotugno, A. (2020). *Land Use Land Cover Analysis as part of the Water Fund Business Case Analysis*. Villanova University, Center for Resilient Water Systems: Pennsylvania.

Smith, V., Shugart-Schmidt, W. & Cotugno, A. (2020). *1 Dimensional Morphological Modeling Methodology and Results*.

Spawn, S.A. & Gibbs, H.K. (2020). *Global Aboveground and Belowground Biomass Carbon Density Maps for the Year 2010.* Oak Ridge, Tennessee, USA.

Spracklen, B.D., Kalamandeen, M., Galbraith, D., Gloor, E. & Spracklen, D. V. (2015). A global analysis of deforestation in moist tropical forest protected areas. *PLoS One* **10**, 1–16.

SSL, (Statistics Sierra Leone). (2017). Sierra Leone 2015 Housing and Population Census: National Analytical Report. *Themat. Rep. Popul. Struct. Popul. Distrib.*

Statistics Sierra Leone. (2011). *Sierra Leone Tourism Statistics Bulletin 2011*. Freetown, Sierra Leone.

Steffan-Dewenter, I., Kessler, M., Barkmann, J., Bos, M.M., Buchori, D., Erasmi, S., Faust, H., Gerold, G., Glenk, K., Gradstein, S.R., Guhardja, E., Harteveld, M., Hertel, D., Höhn, P., Kappas, M., Köhler, S., Leuschner, C., Maertens, M., Marggraf, R., Migge-Kleian, S., Mogea, J., Pitopang, R., Schaefer, M., Schwarze, S., Sporn, S.G., Steingrebe, A., Tjitrosoedirdjo, S.S., Tjitrosoemito, S., Twele, A., Weber, R., Woltmann, L., Zeller, M. & Tscharntke, T. (2007). Tradeoffs between income, biodiversity, and ecosystem functioning during tropical rainforest conversion and agroforestry intensification. *Proc. Natl. Acad. Sci. U. S. A.* **104**, 4973–4978.

Stolton, S., Dudley, N., Belokurov, A., Deguignet, M., Burgess, N.D., Hockings, M., Leverington, F., MacKinnon, K. & Young, L. (2019). Lessons learned from 18 years of implementing the Management Effectiveness Tracking Tool (METT): A perspective from the METT developers and implementers. *Parks* 79–92.

Summers, D.M., Bryan, B.A., Nolan, M. & Hobbs, T.J. (2015). The costs of reforestation: A spatial model of the costs of establishing environmental and carbon plantings. *Land use policy* **44**, 110–121.

Torres, A.B., Marchant, R., Lovett, J.C., Smart, J.C.R. & Tipper, R. (2010). Analysis of the carbon sequestration costs of afforestation and reforestation agroforestry practices and the use of cost curves to evaluate their potential for implementation of climate change mitigation. *Ecol. Econ.* **69**, 469–477.

Tschora, H. & Cherubini, F. (2020). Co-benefits and trade-offs of agroforestry for climate change mitigation and other sustainability goals in West Africa. *Glob. Ecol. Conserv.* **22**.

Turpie, J.K., Forsythe, K.J., Knowles, A., Blignaut, J. & Letley, G. (2017). Mapping and valuation of South Africa's ecosystem services: A local perspective. *Ecosyst. Serv.* **27**, 179–192.

UNDP. (2014). *Tourism concessions in protected natural areas : guidelines for managers*. United Nations Development Programme: New York.

UNEP. (2010). *Sierra Leone: Environment, Conflict and Peacebuilding Assessment. Tech. Rep.* United Nations Environment Programme: Geneva.

UNEP. (2014). *Enforcement of Environmental Law: Good Practices from Africa, Central Asia, ASEAN Countries and China*.

Vellidis, G., Lowrance, R., Gay, P. & Hubbard, R.K. (2003). Nutrient transport in a restored riparian wetland. *J. Environ. Qual.* **32**, 711–726.

Wade, A.S.I., Asase, A., Hadley, P., Mason, J., Ofori-Frimpong, K., Preece, D., Spring, N. & Norris, K. (2010). Management strategies for maximizing carbon storage and tree species diversity in cocoa-growing landscapes. *Agric. Ecosyst. Environ.* **138**, 324–334.

Weisse, M.J. & Naughton-Treves, L.C. (2016). Conservation Beyond Park Boundaries: The Impact of Buffer Zones on Deforestation and Mining Concessions in the Peruvian Amazon. *Environ. Manage.* **58**, 297–311.

WHH. (2011). *Conservation of the Sierra Leonean Western Area Peninsula Forest Reserve (WAPFR): Report on Re-Demarcation of the Western Area Peninsula Forest Reserve*. Welthungerhilfe (WHH): Bonn, Germany.

Wood, S.A., Guerry, A.D., Silver, J.M. & Lacayo, M. (2013). Using social media to quantify nature-based tourism and recreation. *Sci. Rep.* **3**.

World Bank. (2016). *An Introduction to Tourism Concessioning: 14 Characteristics of Successful*

Programs. Washington, DC.

World Bank. (2017). *Sierra Leone: rapid damage and loss assessment of August 14th 2017 landslides and floods in the Western Area*. Washington D.C.

World Bank. (2018). *The World Bank Sierra Leone Multi-City Hazard Review and Risk Assessment*. Washington D.C.

WorldPop (www.worldpop.org - School of Geography and Environmental Science, U. of S., Department of Geography and Geosciences, U. of L. & Departement de Geographie, Universite de Namur) and Center for International Earth Science Information Network (CIESIN), C.U. (2018). Global High Resolution Population Denominators Project - Funded by The Bill and Melinda Gates Foundation.

WTTC. (2020). *Sierra Leone 2020 Annual Research: Key highlights*.

Wunder, S. (2005). *Payments for environmental services: some nuts and bolts*. Center for International Forestry Research: Jakarta, Indonesia.