Republic of Kenya

National Climate Change Action Plan:

Mitigation

Costing of Mitigation Actions

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Mitigation Team:

Deborah Murphy, Seton Stiebert, Dave Sawyer, Jason Dion, Scott McFatridge, International Institute for Sustainable Development

Laura Würtenberger, Lachlan Cameron, Raouf Saidi, Xander van Tilburg, Energy Research Centre of the Netherlands

Peter A. Minang, ASB Partnership for the Tropical Forest Margins at the World Agroforestry Centre

Tom Owino, ClimateCare

Peterson Olum, Climate Change Consultant

International Institute for Sustainable Development

IISD is a Canadian-based, public policy research institute that specializes in policy research, analysis and information exchange. The institute champions sustainable development through innovation, research and relationships that span the entire world

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ECN develops high-quality knowledge and technology for the transition to sustainable energy management. ECN introduces this knowledge and technology to the market. ECN's focus is on energy conservation, sustainable energy and an efficient and clean use of fossil fuels.

ASB Partnership for the Tropical Forest Margins at the World Agroforestry Centre

ASB is the only global partnership devoted entirely to research on the tropical forest margins. ASB aims to raise productivity and income of rural households in the humid tropics without increasing deforestation or undermining essential environmental services.

For further information, please contact:

Deborah Murphy, IISD
Tel: +1-613-238-2296
Email: dmurphy@iisd.ca

Laura Würtenberger, ECN
Tel: +31 88 515 49 48
Email: wuertenberger@ecn.nl

The website for Kenya's Climate Change Action Plan can be accessed at: http://www.kccap.info

Climate & Development Knowledge Network

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Abbreviations

BRT	bus rapid transit
CDM	Clean Development Mechanism
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
ESMAP	Energy Sector Management Assistance Program
GHG	greenhouse gas
GVEP	Global Village Energy Partnerships
ha	hectare
IPCC	Intergovernmental Panel on Climate Change
Ksh	Kenyan Shilling
LPG	liquefied petroleum gas
LRT	light rail transit
MOE	Ministry of Energy
Mt	million tonnes
MW	megawatt
NAMA	nationally appropriate mitigation action
NPV	net present value
REDD+	reducing emissions from deforestation and forest degradation plus the role of conservation, sustainable management of forests and enhancement of forest carbon stocks
SREP	Scaling-Up Renewable Energy
UNFCCC	United Nations Framework Convention on Climate Change

1.0 Introduction

This chapter is part of a larger analysis of low-carbon development options in Kenya, which covers the six mitigation sectors set out in Article 4.1 of the United Nations Framework Convention on Climate Change (UNFCCC): energy, transport, industry, waste, forestry and agriculture. The holistic, sectoral analysis aims to inform Kenya's National Climate Change Action Plan and provides the evidence base for prioritizing low-carbon development options and developing proposals for Nationally Appropriate Mitigation Actions (NAMAs) and REDD+ actions.

The analysis includes a preliminary greenhouse gas (GHG) emissions inventory and reference case projecting GHG emissions to 2030 for the entire Kenyan economy and by sector. The analysis then demonstrates how low-carbon development options can bend down emissions from the proposed reference case in each sector. Recognizing Kenya's development priorities and plans, the analysis also considers how the various options can contribute to sustainable development. The work concludes with the identification and costing of priority actions to enable low-carbon development.

This chapter sets out the methodology and the costing of the six priority low-carbon development options.

2.0 Six Priority Low-carbon Development Options

Six proposed priority areas for low-carbon development were identified in the detailed low-carbon assessment. These areas are priorities because they have large abatement potential, support *Kenya Vision 2030* objectives, offer multiple sustainable development benefits, improve climate resilience and are feasible to implement because of previous experience. The six proposed priority low-carbon development opportunities, abatement potential and sustainable development impacts are listed in Table 1. These six priority areas cover about three-quarters of total abatement potentials found in the low-carbon scenario analysis. Their full deployment would almost halve GHG emissions by 2030 compared to the reference case scenario (cross-sectoral interactions not taken into account).

Table 1: Low-carbon development options

Low-carbon option	Abatement potential to 2030	Sustainable development impacts
Restoration of forests on degraded lands	32.6 MtCO_2e	- Contributes to constitution's goal of 10% tree cover - Biodiversity benefits - Sustainable forest products contribute to improved livelihoods - *Conservation may remove access to forests for communities*
Geothermal	14.1 MtCO_2e	- Energy security, economic growth - *May require relocation of communities/villages*
Reforestation of degraded forests	6.1 MtCO_2e	- Sustained water availability (generation of hydropower) - Contributes to constitution's goal of 10% tree cover - Biodiversity benefits - Sustainable forest products contribute to improved livelihoods

Low-carbon option	Abatement potential to 2030	Sustainable development impacts
Improved cookstoves and LPG cookstoves	5.6 + 1.7 $MtCO_2e$	- Health benefits from reduced indoor air pollution - Lower fuelwood demand and deforestation - Potential cost savings to households
Agroforestry	4.1 $MtCO_2e$	- Increased soil fertility and crop yields, improving livelihoods of farmers and food security - Improved climate resilience - Contributes to goal of 10% tree over on farms
Bus rapid transit (BRT) with light rail transit (LRT) corridors	2.8 $MtCO_2e$	- Reduced traffic congestion - Improved local air quality - Improved road safety

3.0 Priority Low-carbon Option Investment Costs

In the context of this project, investment costs include the total investment costs incurred by public, private and household sectors to deliver the emission reductions outlined in Table 1 that are projected between 2013 and 2030 for the six priority actions. This includes all substantive investment / capital costs and program costs that would be incurred. In this regard, this investment cost analysis represents the total level of investment and not the marginal cost of the investment.

Operational costs are not included for energy low-carbon options (geothermal, mass rapid transit and cookstoves). In the case of the geothermal option, capital costs dominate operational costs. For the mass rapid transit system it was not feasible to determine expected operating costs with reasonable certainty. In the case of cookstoves, substantial operational cost savings are anticipated related to fuel savings from the baseline; however, this benefit to households is not included, as we are primarily interested in the overall level of investment and not the marginal cost of the investment. Agricultural and forestry low carbon options include operational costs as these can be regarded as programme costs.

Table 2 presents the total investment costs over the full lifetime of the analysis (2013-2030). Table 3 presents the investment costs over the next medium term planning period (2013-2017).

Table 2: Summary of total investment costs 2013-2030 for priority low-carbon options

Low carbon option	Investment costs for implementation to 2030 (Ksh and US$, 2011)	Estimated split between public, private sector and household investments	NPV of investment at a 10% real discount rate (Ksh and US$, 2011)
Restoration of forests on degraded lands	Ksh 186 - 290 billion, (US$ 2.2 - 3.4 billion)	100% public	Ksh 69 - 108 billion (US$ 0.81 – 1.3 billion)
Geothermal	Ksh 877 - 1,115 billion (US$ 10.3 - 13.1 billion)	About 45% public / 55% private sector investment assuming current electricity market structure	Ksh 399 - 507 billion (US$ $4.7 - 6.0 billion)
Reforestation of degraded forests	Ksh 48 - 61 billion (US$ 0.56 - 0.71 billion)	100% public	Ksh 18 - 22 billion (US$ 0.21 - 0.26 billion)
Improved cookstoves and LPG cookstoves	Ksh 20 billion (US$ 0.24 billion) Improved cookstoves: Ksh 9 billion (US$ 0.11 billion) LPG stoves: Ksh 11 billion (US$ 0.13 billion)	Improved cookstoves: about 75% consumer costs and 25% public support costs LPG stoves: about 85% consumer cost and 15% public support	Ksh 10 billion (US$ 0.12 billion) Improved cookstoves: Ksh 4.5 billion (US$ 0.053 billion) LPG stoves: Ksh 5.3 billion (US$ 0.062 billion
Agroforestry	Ksh 70 - 117 billion (US$0.82 - 1.38 billion)	100% public	Ksh 26 - 43 billion (US$$0.31 - 0.51 billion)
Bus rapid transit with light rail transit corridors	Ksh 170 billion (US$ 2 billion) BRT: Ksh 21 billion (US$0.25 billion) LRT: Ksh 149 billion (US$1.75 billion	About 75 - 85% public investment cost for infrastructure and 15-25% private costs for vehicle stock	Ksh 79 billion (US$ 0.93 billion) BRT: Ksh 9.9 billion (US$0.116 billion) LRT: Ksh 69 billion (US$0.81 billion)
Total of 6 Priority Low-carbon Options	**Ksh 1,371 - 1,773 billion (US$16.1 - 20.8 billion)**	**62% public, 38% private, 1% Households**	**Ksh 600 - 769 billion (US$7.05 - 9.04 billion)**

Table 3: Summary of investment costs for next medium term planning period (2013-2017)

Priority low-carbon option	Investment cost (KSh 2011 billion)			Net present value of investment (KSh 2011 billion)		
	Average	Low	High	Average	Low	High

Restoration of forests on degraded lands	47.1	36.7	57.4	29.2	22.8	35.7
Improved cookstoves and LPG cookstoves	6.3	6.3	6.3	4.7	4.7	4.7
Geothermal energy	314.9	277.2	352.6	231.3	203.6	259.0
Reforestation of degraded lands	7.0	6.1	7.8	4.5	4.0	5.1
Agroforestry	12.1	9.1	15.1	7.9	5.9	9.8
Bus rapid transit with light rail transit corridors	55.6	55.6	55.6	40.8	40.8	40.8
Total planning period (2013-2017)	***443***	***391***	***495***	***318***	***282***	***355***

Priority low-carbon option	Investment cost (US$2011 million)			Net present value of investment (US$2011 million)		
	Average	Low	High	Average	Low	High
Restoration of forests on degraded lands	553	431	675	343	268	419
Improved cookstoves and LPG cookstoves	74	74	74	55	55	55
Geothermal energy	3,700	3,258	4,143	2,718	2,393	3,043
Reforestation of degraded lands	82	72	92	53	47	60
Agroforestry	142	107	177	92	69	115
Bus rapid transit with light rail transit corridors	654	654	654	480	480	480
Total planning period (2013-2017)	***5,205***	***4,596***	***5,815***	***3,742***	***3,311***	***4,172***

The costing methodology used to develop investment cost estimates is presented in the following section 4. In this section we review the data sources, calculations and final investment costs for each of the six priority actions.

3.1 Restoration of Forests on Degraded Lands

Funding and implementation of actions to restore forests on degraded lands will eventually lead to reduced deforestation and improved forest management and associated co-benefits, such as improved water availability, hydropower generation, reduced flooding and landslides, and sustainable use of forest products such as fuelwood, charcoal and medicines. The low-carbon scenario considers that 960,000 hectares of degraded lands would be restored between 2015 and 2030.

Costs for this action were based on reported costs for the protected area management in the Kakamega Forest and an analysis of the International Small Group and Tree Planting Program in Kenya.[1,2] These reported costs are presented in Table 4.

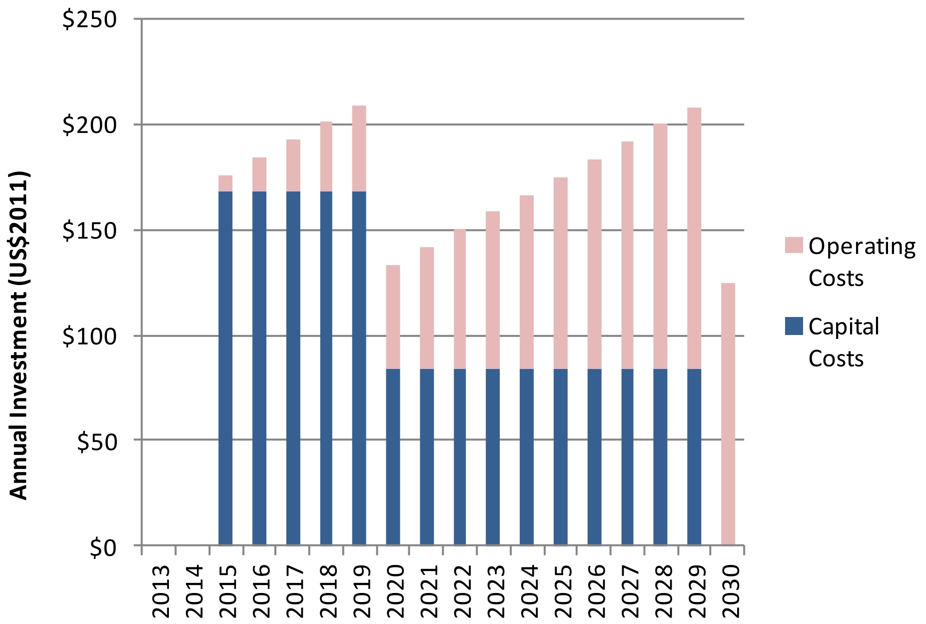
Table 4: Project investment cost components for reforestation of degraded lands projects

Revealed costs from analysis	Low (US$)	High (US$)
Costs per hectare	207	323.75
Tonnes CO_2/ha/year	33.92	33.92
$/tonne CO_2	**6.10**	**9.54**

The high value of abatement cost determined from the literature of US$9.54 was used in the priority action cost analysis. The range of investment cost was based on the distribution of the costs per hectare around this abatement cost. Based on the estimated potential of emission reductions that can be achieved for the reforestation of degraded lands action, total investment costs of $2,181 - $3,411 (US$2011) are estimated.

Capital and programme/operating costs were then distributed over the project lifetime between 2015 and 2030. Capital costs to cover program costs and set-up costs were front-loaded for the action and assumed that 50 per cent of capital costs were invested in the first five years of the program and that the remaining 50 per cent was distributed over the remaining 10 years of the program. Programme/operating costs were scaled to the emission reductions that are achieved over time. A distribution of total investment costs for the action is presented in Figure 1 below.

Figure 1: Temporal distribution of investment for reforestation of degraded lands (US$2011 million)



Applying this disbursement resulted in investment costs for the entire project lifetime and for the next medium term planning period, 2013-2017, set out in Table 5.

Table 5: Investment costs for restoration of forests on degraded lands 2013-2030 and for next medium term planning period 2013-2017

Investment cost		Average	Low	High
Total investment cost over project lifetime (2013-2030)	US$2011 million	2,796	2,181	3,411
	NPV @ 10% US$2011 million	1,036	808	1,264
	KSh 2011 billion	237.9	185.6	290.3
	NPV @ 10% KSh 2011 billion	88.1	68.8	107.5
Total investment cost medium-term planning period (2013-2017)	US$2011 million	553	431	675
	NPV @ 10% US$2011 million	343	268	419

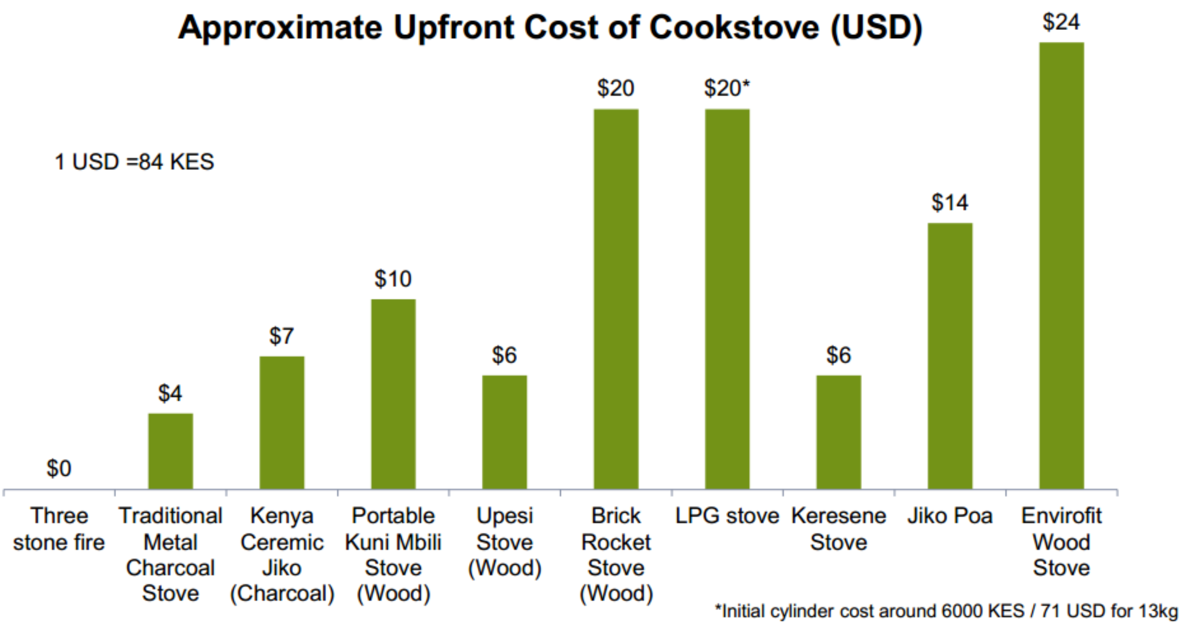
	KSh 2011 billion	47.1	36.7	57.4
	NPV @ 10% KSh 2011 billion	29.2	22.8	35.7

3.2 Improved Cookstoves

Improved cookstoves and the use of liquefied petroleum gas (LPG) for cooking increase climate resilience due to lower fuelwood requirements and decreased pressure on forests. The use of LPG and improved fuelwood and charcoal stoves for cooking have significant health benefits because reduced indoor air pollution decreases the incidence of respiratory diseases. Moreover, both options can lead to cost savings for users, depending on whether fuelwood is collected or purchased, and the price for LPG. The low-carbon scenario assumes a 100 per cent penetration of improved cookstoves by 2030, with the cookstoves having a 50 per cent efficiency improvement over equipment in 2012.

Costs for this action were based on reported costs and data from a recent study of improved cooking technologies in Kenya.[3] This study presented an estimate for the number of households in Kenya in 2007 (based on previous reports), three different estimates for the number of improved cookstoves in Kenya (from different sources), purchase costs for various stove types (Figure 2) and penetrations of improved cook stoves by type and market segment (such as rural versus urban).

Figure 2: Approximate upfront cost of cookstoves (US$)



Source: Global Village Energy Partnerships (GVEP) International, 2012. Global Alliance for Clean Cookstoves: Kenya Market Assessment - Sector Mapping. *Nairobi: GVEP International.*

The total number of households in different segments in 2007 (Table 6) were scaled up to current account for current estimates of population. This, along with the estimates of the current penetrations of different types of stoves in each segment, allowed the total number of improved cookstoves of different types required for 100 per cent penetration to be calculated. This gave a figure of approximately 3 million improved charcoal cookstoves and 5 million improved wood stoves. This was used with average costs of improved cookstoves to estimate the total cost to customers for improved cookstoves based on current numbers of households. Future increases in household numbers were not accounted for in this first order estimate of costs. Programme costs in support of reaching full penetration of improved cookstoves by 2030 were estimated from the existing EnDev programme that has been successfully working in Kenya with a budget of approximately Euro 6 million until the end of 2012.[4,5] These costs were extrapolated up to the total number of improved cookstoves in the low-carbon scenario, giving a total programme/support cost in the order of US$ 30 million.

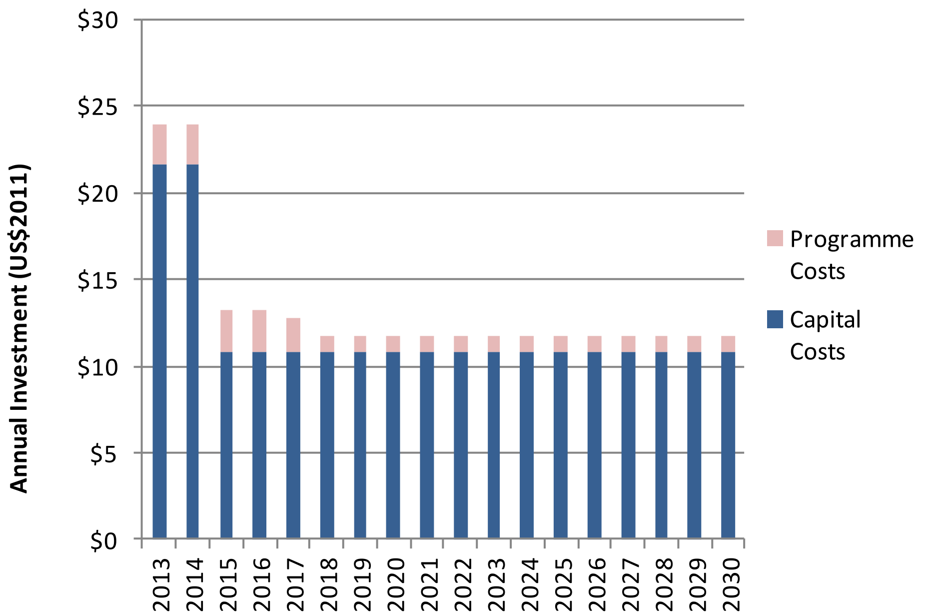
Table 6: Number of households and number of stoves from different sources (US$)[6]

	Rural households			Urban households		
	Poor (<$1)	Mid ($1-3)	Upper (>$3)	Poor (<$1)	Mid ($1-3)	Upper (>$3)
Households	2,690,000	1,580,000	1,110,000	1,260,000	950,000	320,000
Total households	7,910,000					
% of total	34%	20%	14%	16%	12%	4%
Stove ownership	2,250,000 (2007 estimate)					
	1,500,000 (2004 estimate)					
	3,100,000 (2006 estimate)					

Source: Global Village Energy Partnerships (GVEP) International, 2012. Global Alliance for Clean Cookstoves: Kenya Market Assessment - Sector Mapping. *Nairobi: GVEP International.*

Costs were then distributed over the project lifetime between 2013 and 2030. Capital costs were front-loaded for the action and assumed that 20 per cent of capital costs were invested in the first two years of the program and that the remaining 80 per cent was distributed over the remaining 16 years of the program. Programme costs were also assumed to be front-loaded for the action and 40 per cent of programme costs were invested in the four years of the program and the remaining 60 per cent was distributed over the remaining 12 years of the program. A distribution of total investment costs for the action is presented in Figure 3 below.

Figure 3: Temporal distribution of investment for improved cookstoves (US$2011 million) (Note that fuel operating costs were not included in the calculation)



Applying this disbursement resulted in investment costs for the entire project lifetime and for the next medium term planning period, 2013-2017, set out in Table 7.

Table 7: Investment costs for improved cookstoves 2013-2030 and for next medium term planning period 2013-2017

	Investment cost		Average	Low	High
TOTAL (2013-2030)	Total investment cost over project lifetime (2013-2030)	US$2011 Million	240	240	240
		NPV @ 10% US$2011 Million	109	109	109
		KSh 2011 Billion	20.4	20.4	20.4
		NPV @ 10% KSh 2011 Billion	9.3	9.3	9.3
(2013-2017)	Total investment cost medium-term planning period (2013-2017)	US$2011 Million	74	74	74
		NPV @ 10% US$2011 Million	55	55	55
		KSh 2011 Billion	6.3	6.3	6.3
		NPV @ 10% KSh 2011 Billion	4.7	4.7	4.7

3.3 Geothermal Energy

The increased deployment of geothermal power would not only lead to lower GHG emissions compared to electricity generation based on fossil fuels, but geothermal power can also provide low-cost base load electricity generation, therefore facilitating economic activity and development. It would also reduce the current reliance on hydropower thereby improving climate resilience.

The low and high range of investment costs into geothermal power generation were estimated by calculating average values of investment costs per megawatt (MW) of geothermal electricity developed based on the three studies presented in Tables 8 and 9. The investment costs per MW were then multiplied by the additional geothermal generation capacity to be added until 2030 according to the low-carbon development scenario in order to get the total investment costs.

Table 8: Low range of values for investment costs per MW of geothermal electricity generation

Ministry of Energy (2011) – Scaling-Up Renewable Energy Investment Plan for Kenya[7]	US$3.625 million / MW (see Table 7 – excludes rig procurement and capacity building)
Ministry of Energy (2011) – Least Cost Power Development Plan[8]	US$3.65 million / MW
Energy Sector Management Assistance Program (2012) – Geothermal Handbook: Planning and Financing Power Generation[9]	US$3.92 million / MW (median value)

Table 9: High range of values for investment costs per MW of geothermal electricity generation

Ministry of Energy (2011) – Investment Plan for Kenya[10]	US$5.06 million / MW (based on risk-adjusted costs for each component)
Energy Sector Management Assistance Program (2012) – Geothermal Handbook: Planning and Financing Power Generation[11]	US$4.04 Million / MW (upper value)

To arrive at the high end of the estimates based on the Scaling-Up Renewable Energy (SREP) investment plan, the breakdown of investment costs provided in the SREP investment plan was risk adjusted with estimated percentage failure rates based on literature and expert input (see Table).[12] Table also shows the assumed split between public and private investment costs, assuming that the private sector would carry the costs for the construction of power plants and for transmission and substations.

Table 10: Risk-adjusted investment costs for 200 MW of geothermal energy development in Kenya and split between public and private investment

	Public investment costs for 200MW (including Geothermal Development Corporation, Multilateral Development Banks, etc.) [million US$]	Private investment costs for 200 MW [million US$]	Risk factor (percent failure)	Risk-adjusted costs for 200 MW [million US$]
Project preparation	82		0	82
Exploratory program (3 wells)	11		80	53
Appraisal program (6 wells)	21		30	30
Feasibility study	2		20	3
Production drilling (35 wells)	123		5	129
Reinjection wells (8 wells)	28		5	29
Steamfield development	37		5	39
Wellhead equipment	22		5	23
Power plant construction		386	5	406
Transmission and substations		14	5	15
Total		**725**		**809**

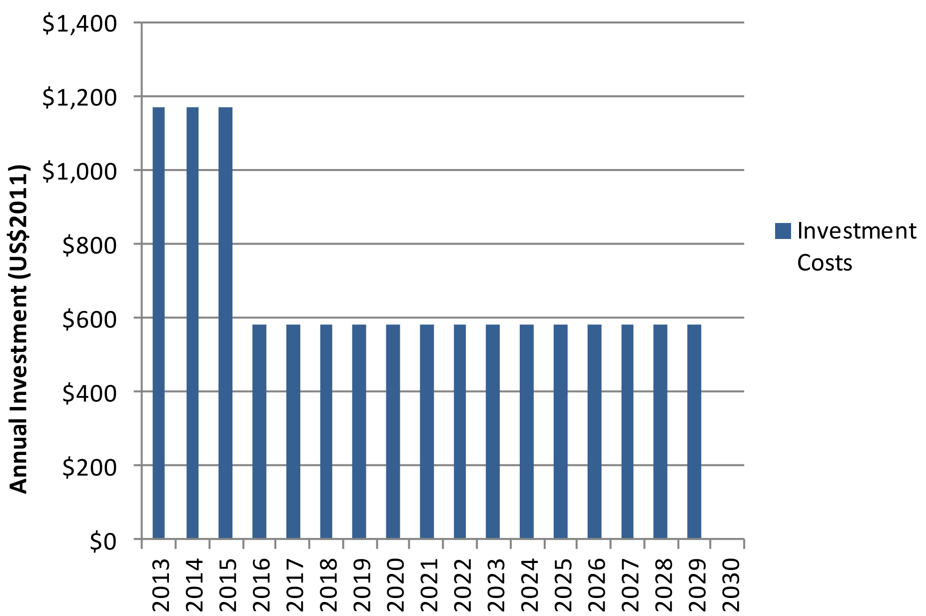
Percentage private / public costs	45%	55%		

Source: Ministry of Energy. 2011. Scaling-Up Renewable Energy (SREP) Investment Plan for Kenya. *Nairobi: Government of Kenya; and expert input.*

Capital costs were then distributed over the project lifetime between 2013 and 2030. Capital costs costs were front-loaded for the action and assumed that 30 per cent of capital costs were invested invested in the first three years of the program and that the remaining 70 per cent was distributed over the remaining 14 years of the program. A distribution of total investment costs costs for the action is presented in

Figure 4 below.

Figure 4: Temporal distribution of investment for geothermal energy (US$2011 million)



Applying this disbursement resulted estimates of investment costs for the entire project lifetime and for the next medium term planning period, 2013-2017, set out in Table 11.

Table 11: Investment costs for geothermal energy 2013-2030 and for next medium term planning period 2013-2017

<table>
<tr><th></th><th colspan="2">Investment cost</th><th>Average</th><th>Low</th><th>High</th></tr>
<tr><td rowspan="5">TOTAL (2013-2030)</td><td rowspan="5">Total investment cost over project lifetime (2013-2030)</td><td>US$2011 million</td><td>11,700</td><td>10,300</td><td>13,100</td></tr>
<tr><td>NPV @ 10% US$2011 million</td><td>4,446</td><td>3,914</td><td>4,978</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>KSh 2011 billion</td><td>995.7</td><td>876.5</td><td>1,114.8</td></tr>
<tr><td>NPV @ 10% KSh 2011 billion</td><td>378.4</td><td>333.1</td><td>423.7</td></tr>
<tr><td rowspan="5">(2013-2017)</td><td rowspan="5">Total investment cost medium term planning period (2013-2017)</td><td>US$2011 million</td><td>2,224</td><td>1,958</td><td>2,490</td></tr>
<tr><td>NPV @ 10% US$2011 million</td><td>434</td><td>382</td><td>486</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>KSh 2011 billion</td><td>189.2</td><td>166.6</td><td>211.9</td></tr>
<tr><td>NPV @ 10% KSh 2011 billion</td><td>36.9</td><td>32.5</td><td>41.3</td></tr>
</table>

3.4 Reforestation of Degraded Forests

Funding and implementation of actions to reforest degraded forests will eventually lead to improved forest management and associated co-benefits, such as improved water availability, hydropower generation, reduced flooding and landslides, and sustainable use of forest products such as fuelwood, charcoal and medicines. The low-carbon scenario considers a programme where 240,000 hectares of degraded land that was previously forests would be replanted between 2015 and 2030.

Costs for this action were based on reported costs from several projects related to the Aberdare Range/ Mt. Kenya Small Scale Reforestation Initiative project (a Clean Development Mechanism project).[13] These costs were considered to be highly transfereable to the priority reforestation action as they were Kenyan specific and were fully loaded costs that included program costs and incentive payments that are required to overcome implementation barriers and ensure the success of the action. Other costs identified in the literature also substantiated that this level level of investment is typical for this type of action. Table 12 identifies project related costs for the Kiriti and Kamae-Kipipiri reforestastion projects and their relative cost effectiveness in US$/tonne of emissions reduced.

Table 12: Project investment cost components for reforestation of degraded forests projects (US$)

Project cost components	Kiriti project	Kamae-Kipipiri	TOTAL
1. Community mobilization and networking	45,983	53,026	99,009
2. Field training facility and follow up	92,709	106,908	199,617
3. Nursery management	19,052	21,970	41,022
4. Tree planting (stakeholder consultations and involvement)	25,529	29,440	54,969
5. Incentive payment for surviving trees	37,567		80,888
6. Trees after care and follow-up records	1,853	2,137	3,990
7. Kick-starting sustainability activities	55,322	63,795	119,117

8. Tree survival monitoring	22,738		48,958
9. Project management costs	42,836	49,397	92,233
10. Land lease	3,810	4,394	8,204
11. Program administration related costs	28,016	32,307	60,323
Total Costs	**$375,415**	**$432,915**	**$808,330**

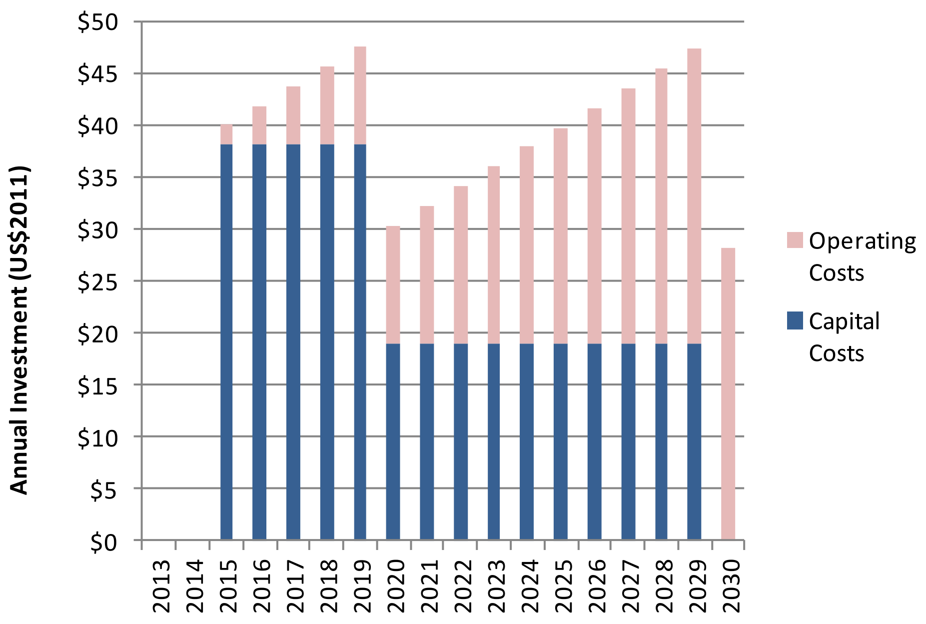
Average Annual Project Emission Reductions (tonnes)	8,809	8,542	17,351
Assumed Capital Recovery Factor	0.15	0.15	0.15
Additional Operational Costs (%)	10%	10%	10%

Total Annual Costs (US$/year)	$93,854	$108,229	$202,083
Abatement Cost (US$/tonne)	**$10.65**	**$12.67**	**$11.66**

The range in abatement cost between US$10.65 and US$12.67 was then used in the priority action cost analysis. Based on the estimated potential of emission reductions that can be achieved for the reforestation of degraded lands action, total investment costs of US$560 - $712 (US$2011) are estimated.

Capital and operating costs were then distributed over the project lifetime between 2015 and 2030. Capital costs to cover program costs and set-up costs were front-loaded for the action and assumed that 50 per cent of capital costs were invested in the first five years of the program and that the remaining 50 per cent was distributed over the remaining 10 years of the program. Operating costs were scaled to the emission reductions that are achieved over time. A distribution of total investment costs for the action is presented in Figure 5 below.

Figure 5: Temporal distribution of investment for reforestation of degraded forests (US$ 2011 million)



Applying this disbursement resulted estimates of investment costs for the entire project lifetime and for the next medium-term planning period, 2013-2017, set out in Table 13.

Table 3: Investment Costs for reforestation of degraded forests 2013-2030 and for next medium term planning period 2013-2017

	Investment cost		Average	Low	High
TOTAL (2013-2030)	Total investment cost over project lifetime (2013-2030)	US$2011 million	636	560	712
		NPV @ 10% US$2011 million	235	207	264
		KSh 2011 billion	54.1	47.6	60.6
		NPV @ 10% KSh 2011 billion	20.0	17.6	22.4
(2013-2017)	Total investment cost medium term planning period (2013-2017)	US$2011 million	82	72	92
		NPV @ 10% US$2011 million	53	47	60
		KSh 2011 billion	7.0	6.1	7.8
		NPV @ 10% KSh 2011 billion	4.5	4.0	5.1

3.5 Agroforestry

Funding and implementation of agroforestry actions will improve foods security, livelihoods, and climate resilience, in addition to sequestering carbon. The low-carbon scenario considers that 281,000 hectares of existing arable cropland and grazing land that have medium or high agricultural potential will be converted to agroforestry between 2015 and 2030.

Costs for this action were based on reported costs from two available studies that represented experience with agroforestry projects in eastern Africa.[14,15] Both studies presented marginal abatement costs and included household revenues from carbon payments and increased agricultural productivity. In order to determine total investment costs it was necessary to exclude household revenue from the reported marginal abatement costs. Table 14 below summarizes the range of costs reported on a per tonne of emission reductions basis.

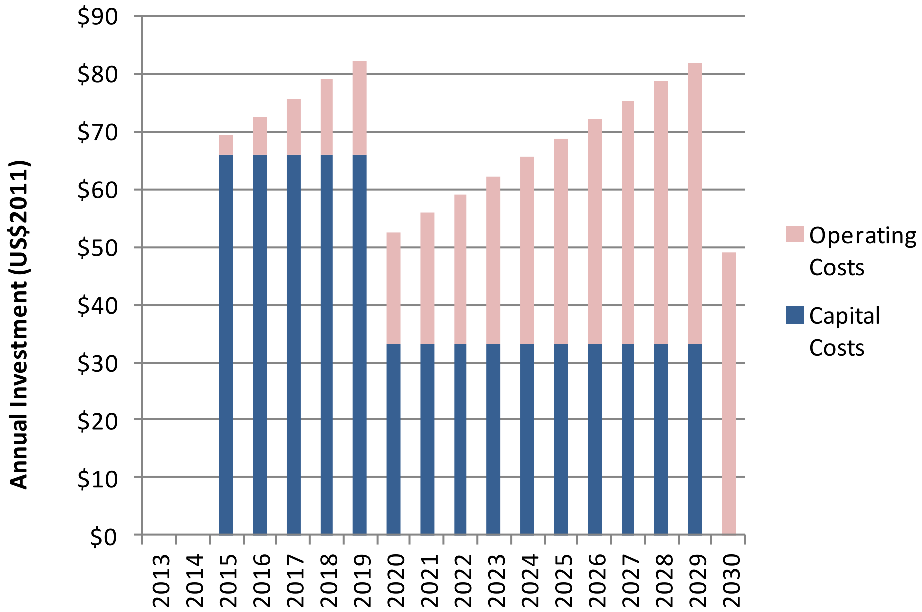
Table 14: Project investment cost components for agroforestry projects (US$)

Revealed costs from analysis	Low	High	Average
Marginal abatement costs (US$/tonne)	6.85	19.60	13.23
Household revenues (US$/tonne)	15.20	17.05	16.12
Total abatement cost (US$/tonne)	**$22.06**	**$36.61**	**$29.37**

The high and low abatement costs determined from the literature of US$22.06 - US$36.61 were used in the priority action cost analysis. The range of investment cost was based on the distribution of the costs per hectare around this abatement cost. Based on the estimated potential of emission reductions that can be achieved for the reforestation of degraded lands action, total investment costs of US$826 - US$1,374 (US$2011) are estimated.

Capital and operating costs were then distributed over the project lifetime between 2015 and 2030. Capital costs to cover program costs and set-up costs were front-loaded for the action and assumed that 50 per cent of capital costs were invested in the first five years of the program and that the remaining 50 per cent was distributed over the remaining 10 years of the program. Operating costs were scaled to the emission reductions that are achieved over time. A distribution of total investment costs for the action is presented in Figure 6 below.

Figure 6: Temporal distribution of investment for agroforestry (US$2011 million)



Applying this disbursement resulted estimates of investment costs for the entire project lifetime and for the next medium-term planning period, 2013-2017, set out in Table 15.

Table 15: Investment costs for Agroforestry 2013-2030 and for next medium term planning period 2013-2017

	Investment cost		Average	Low	High
TOTAL (2013-2030)	Total investment cost over project lifetime (2013-2030)	US$2011 million	1,100	826	1,374
		NPV @ 10% US$2011 million	408	306	509
		KSh 2011 billion	93.6	70.3	116.9
		NPV @ 10% KSh 2011 billion	34.7	26.1	43.3
(2013-2017)	Total investment cost medium term planning period (2013-2017)	US$2011 million	142	107	177
		NPV @ 10% US$2011 million	92	69	115
		KSh 2011 billion	12.1	9.1	15.1
		NPV @ 10% KSh 2011 billion	7.9	5.9	9.8

3.6 Bus Rapid Transit with Light Rail Transit Corridor

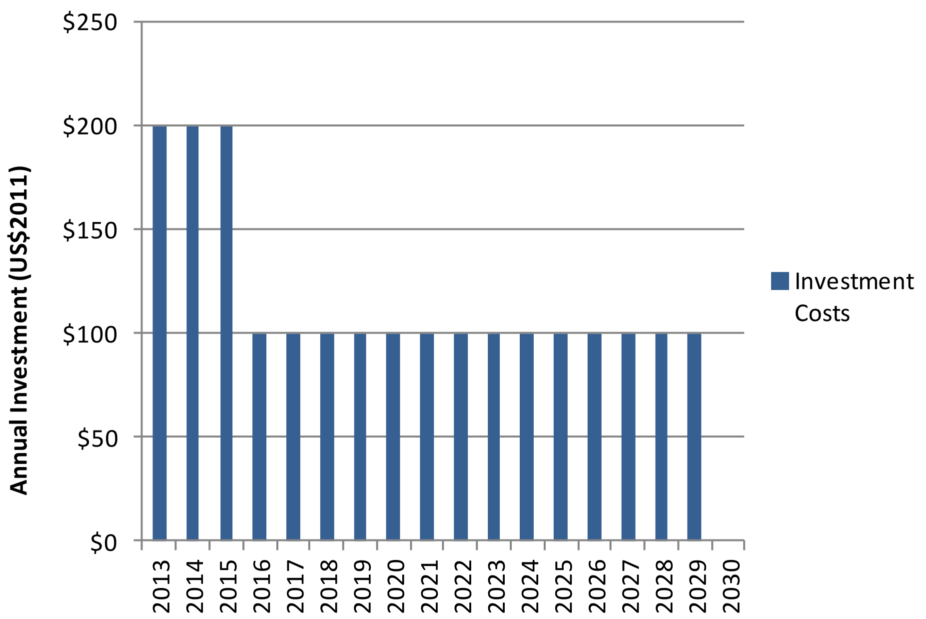
The introduction of an extensive mass transit system for greater Nairobi in the form of bus rapid transit (BRT) corridors - complemented by some light rail transit (LRT) corridors -

stands out as a potential priority action in the transport sector due to its significant benefits in terms of relieving traffic congestion, improving local air pollution and increasing road safety. It would also be in line with government priorities as the Government of Kenya has already started to secure funding for these investments. After initial experience has been collected in Nairobi, such a system could be replicated in other large urban areas in the country. The scenario assumes that the mass transit system from a recent feasibility study is implemented, but with BRT as the dominant mode of public transport complimented by some lesser use of LRT.[16] The somewhat ambitious schedule in the feasibility study is assumed to be delayed by five years, with a conservative level of BRT infrastructure in place by 2015. For use in costing, an estimate of the number of kilometres of both BRT and LRT line in service every 5 years until 2030 was made from the feasibility study, by assuming that the construction schedule for each line is delayed by 5 years. However one BRT pilot corridor is completed by 2015

Cost estimates for the BRT system were based on an average of two major reviews of actual BRT costs, considering only those BRT systems that were deployed in developing economies.[17,18] This was used instead of the costs given in the 2011 feasibility study, as these were found to be three to four times higher than commonly observed in other countries, which was not felt to be justified. The final figure used was approximately US$3 million per kilometre including vehicle stock. Cost estimates for LRT were based on a 2011 study of the mass transit options for greater Nairobi (that was also used to estimate the mitigation potential of this option) which was compared with, and found to be in line with, other estimates of LRT system costs.[19,20] The final figure used was US$58.6 million per kilometre including rolling stock. For percentage of private investment in total costs, it was assumed that vehicle/rolling stock is paid for by the private sector on the basis of awarded contracts for system operation. This scheme can be challenging to realise, but has been seen in other mass transit systems around the world.

Capital and operating costs were then distributed over the project lifetime between 2013 and 2030. Capital costs were front-loaded for the action and assumed that 30 per cent of capital costs were invested in the first three years of the program and that the remaining 70 per cent was distributed over the remaining 14 years of the program. A distribution of total investment costs for the action is presented in Figure 7 below.

Figure 7: Temporal distribution of investment for BRT with LRT corridor (US$2011 million)



Applying this disbursement resulted estimates of investment costs for the entire project lifetime and for the next medium term planning period, 2013-2017, set out in Table 16.

Table 16: Investment costs for BRT with LRT corridor 2013-2030 and for next medium term planning period 2013-2017

	Investment cost		Average	Low	High
TOTAL (2013-2030)	Total investment cost over project lifetime (2013-2030)	US$2011 million	2,000	2,000	2,000
		NPV @ 10% US$2011 million	930	930	930
		KSh 2011 billion	170.2	170.2	170.2
		NPV @ 10% KSh 2011 billion	79.2	79.2	79.2
(2013-2017)	Total investment cost medium term planning period (2013-2017)	US$2011 million	654	654	654
		NPV @ 10% US$2011 million	$80	480	480
		KSh 2011 billion	55.6	55.6	55.6
		NPV @ 10% KSh 2011 billion	40.8	40.8	40.8

4.0 Methodology

The methodology seeks to determine the temporal distribution of investment costs that are incurred by public, private and household sectors over the 2013 - 2030 time period for the six priority low-carbon options. Investment costs includes all capital costs and program costs that would be incurred to deliver the emission reductions in Kenya. In this regard, this investment cost analysis represents the total level of investment and not a net present value of the investments nor marginal costs related to a baseline. For energy low carbon options it does not include operating costs and cost savings related to changes in investment from the baseline. For example, costs reductions related to fuel savings are not included in the analysis. However, since operating costs for agricultural and forestry low carbon options are effectively programme costs these are included in the estimates.

The costing methodology follows five steps, described in the following sub-sections.

1. Conduct bottom-up analysis to determine total investment costs for six priority low-carbon options.
2. Estimate a range of total investment costs.
3. Determine the contribution of investment from public, private and household sectors.
4. Estimate the disbursement of total investment costs over the 2013 to 2030 time-period.
5. Calculate the investment for the next medium term plan period (2013-2017).

4.1 Investment Costs Analysis

Total investment costs were determined based on bottom-up analysis using cost data gathered from literature. Preference was given to cost estimates that were specific to the development of the low-carbon options in Kenya or for projects that had faced similar circumstances and barriers to implementation. As much as possible investment costs were broken down into detailed capital and programme cost components for each of the low-carbon options. Different cost components included technology costs (such as equipment NS supporting infrastructure), development costs (such as exploration and feasibility) and program support costs (such as monitoring, training and project management).

Investment costs for all carbon-options were expressed in US$. All costs were converted to 2011 US$ and KSh based on the Purchasing Power Parity index and current currency exchange rates.

4.2 Range of Total Investment Costs

Where possible, low and high investment costs reported in the literature were used to estimate a cost range that reflects the uncertainty associated with estimating the cost of the low-carbon options.

4.3 Contribution of Private, Public and Household Sectors

It is expected that the overall investment for low-carbon options will be raised from private, public and household sectors. The public sector includes both the government of Kenya and potential donors. Depending on the low-carbon option, the contribution of each sectors can be very different and a literature review and expert assessment were used to determine the relative contribution as a percentage of total investment that is borne by each of these sectors.

4.4 Disbursement of Investment

The literature provides some indication of how total investments are likely to be distributed over time for different low-carbon options. In most cases capital investments must be made several years before operation and emission reductions are achieved. Development and program support costs also must be made in advance in order to provide a foundation for successful implementation. For each of the low-carbon options under consideration, capital costs and programme costs were mostly front-loaded. Conversely where operational costs were estimated, they were distributed based on the implementation of the low-carbon options and the achievement of emission reductions over the 2013 to 2030 time period. In other words, operational costs were assigned the same distribution as emission reductions.

Disbursement of the costs as described above permits the calculation of the Net Present Value of the investment. The net present value was calculated assuming a discount rate of 10 per cent. A discount rate of 10 per cent is typical for public investments in Kenya.

Costs were disbursed for the different low-carbon options between the period 2013 and 2030.

4.5 Medium-term Investment Period (2013-2017)

Based on the disbursement of investment costs identified in the previous step, the annual investment costs for the period between 2013 to 2017 are added to identify total investment costs for the next medium term investment period.

5.0 Conclusion

Significant investments will be required and a series of barriers will need to be addressed before the low-carbon opportunities can be realised. Implementing the six priority low-carbon actions would require investments of Ksh 1,371 - 1,773 billion (US$ 16.12 - 20.84 billion) until 2030 (equivalent to a Net Present Value of Ksh 600 - 770 billion at a real discount rate of 10 per cent). Out of these investment costs, it is estimated that Ksh 839 - 1,110 billion will have to be borne by the public sector, with the remaining costs covered by private sector and household investments. A large challenge is financing the higher upfront costs of low-carbon investments. Kenya sees clear potential to make effective use of bilateral and multilateral funding, as well as international climate finance mechanisms – such as the Green Climate Fund and emerging NAMAs and REDD+ mechanisms – in moving forward on the Action Plan, in addition to systematic domestic support.

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