EU- UNEP AFRICA LOW EMMISIONS DEVELOPMENT STRATEGIES

AFRICA-LEDS

Low Emissions Development Strategies (LEDS) Modelling Support – Kenya Report Jan 2018 - March 2019

Contents

1. BACKGROUND INFORMATION

The negotiation & unanimous adoption of the Paris Agreement in COP21 by countries across the globe, including in Africa constituted a defining moment for low emissions development globally. This is because the agreement established the high-level Low Emissions Development Strategies (LEDS) policy positions agreed to by countries to guide LEDS actions across the globe. At the COP22, heads of state and government adopted the Marrakech Action Proclamation, committing to fully implement the agreement(UNFCCC, n.d.).

Among the novel provisions of this Paris Agreement enhancing its country-driven-ness is Article 3 on Nationally Determined Contributions (NDCs). These lay the basis for demand-driven, country-led LEDS interventions towards implementing the agreement. Hence provide a foundational basis to ensure any LEDS support to countries in the region can be tailored to respond to these country-defined priorities.

To this end, the UN Environment Programme (UNEP), the European Commission (EC), and partners including the Africa LEDS Partnership (AfLP) and LEDS Global Partnership (LEDS GP) came together in an initiative to support demand driven LEDS actions in countries through the EU-UNEP Africa Low Emissions Development Strategies (Africa LEDS) project. This project aimed at supporting countries establish strong analytical frameworks to facilitate long-term LEDS policy decision making consistent with their respective climate objectives and socio-economic development priorities as stipulated in their NDCs, development visions and LEDS plans.

The overall objective of the project was to assist Kenya establish requisite modelling & analytical capacity to inform concrete LEDS policies and plans and their implementation for prioritized low emission, climate-resilient, and resource efficient socio-economic development consistent with Nationally Determined Contribution (NDCs) & other LEDS plans.

To achieve the above, the project specifically aimed at:

- Training and demonstrating use of modelling & analytical tools to inform long term LEDS policy decisions and their implementation to actualize LED priorities as encapsulated in the country NDCs and LEDS plans
- Quantifying and assessing socio-economic impacts of mitigation options with a view to informing the policy-making process
- Transferring relevant modelling technologies / suit of models relevant to country priorities as established in development visions, NDCs & other LEDS plans
- Supporting country technical team in conducting tangible activities as demonstration of improved modelling capacity. Target activity is establishment of GHG emissions baseline among priority sectors highlighted in NDCs.

2. ACHIEVEMENTS / ACCOMPLISHMENTS

Six workshops spanning over different periods have been held to build capacity in modelling skills for the team and to develop the Kenyan model as follows:

- 1 day workshop on 22 Feb 2018
- 4 days workshop on 16-19 April 2018
- 3 days workshop 2-5 July 2018
- 3 days workshop 15-17 august 2018
- 3 days workshop 25-27 Sept 2018
- 4 days workshop 29 Oct-2 Nov 2018

Picture 1: Modelling teams in Session

Component 2– modelling actions

In the initial stages the experts reviewed the priority low carbon options in the National Climate Change Action Plan (NCCAP-2013-2017) and also the sectoral "unpacking" of the NDC. The NCCAP is a framework for Kenya to deliver on its Nationally Determined Contribution (NDC) under the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC). The prioritization was based on the mitigation potential and sustainable development impacts. Within the strategic approach of balancing climate resilience and socioeconomic priorities, the team chose clean cooking solutions (Improved cook stoves) under the Energy sector and Agro-forestry under AFOLU as priority areas for modelling socio-economic impacts.

Modelling Clean cooking solutions: Biomass remains the dominant energy source in Kenya. Its use has greatly undermined national action on mitigation of climate change. The sessional paper number of 2004 sort to reduce firewood dependency, national climate response strategy calls for alternative sources, the energy policy draft of 2015 and the energy bill of 2015 also calls for replacement of solid fuels with non-solid fuels. We build this forecast supported by NCCAP 2018/2022 targets and extend the forecast to 2030 by the use of LEAP tool to assess mitigation benefits.

Modelling Agro- forestry: An attempt is made to modelling of transformation of land use with a focus on agroforestry. The team sought to investigate the 10% agricultural land transformation as stipulated in the agricultural land act of Kenya 2009. Section five of the agricultural act requires 10% of land under farm forestry and the Kenya intended nationally determined contribution requires atleast 10% forest cover in 2030. We used Abacus model to examine the socio-economic gains of ensuring 10% agro forestry in Kenya.

The achievements for the two priority sectors are discussed further below..

2.1 BUILDING MITIGATION SCENARIOS IN CLEAN COOKING

Low emissions development scenarios were derived from the National Climate change action plan 2018-2022. The NCCAP is the country's overall climate change response instrument and provides priority actions to be implemented in 5 years phases. In order to demonstrate the benefits of mitigation interventions, targets in strategic objective 7a, outcomes 3, 5 and 6 from the NCCAP 2018-2022 were selected for modelling as illustrated in table 4 below (MEF, 2018).

Strategic Objective 7a: Ensure an electricity supply mix based mainly on renewable energy that is resilient to climate change and promotes energy efficiency; encourage the transition to clean cooking that reduces the demand for biomass.

National-level Indicators:

- Renewable energy share in the total electricity generation mix - %
- Households using biomass for energy - %
- Proportion of households using LPG - %
- Freight moved by rail - %

- Explain how the models have been integrated to inform NDCs implementation policy decisions

The NDC on energy focuses on

I. Improve energy efficiency and energy conservation
II. Promote the transition to clean cooking with alternative fuels, such as liquefied petroleum gas (LPG), ethanol and other clean fuels in urban areas
III. Encourage the uptake of clean biomass (charcoal and wood) cookstoves and alternatives in rural areas

Modelled scenarios included, business as usual scenario, improved energy efficiency, energy transition and combined scenario (energy efficiency and energy transition).

A. Business as usual scenario

Business as usual scenario assumes no major changes in current trends of national growth and energy use patterns. The scenario thus retains the current trend of population and GDP growth and urbanization. The rapid electrification rate especially for the urban and rural areas of 30% and 24% (Kenya Power, 2018) respectively was as a result of government and multilateral program in the last mile connectivity project and additional geothermal power plants. In the baseline scenario, 100% urban electrification is targeted by 2025 and 30% rural electrification by 2030. This can potentially be achieved based on the high electrification growth trend (Kenya

Power, 2018).

B. Improved energy efficiency

Improved energy efficiency scenario is based on outcome 6 of the NCCAP 2018 – 2022 targets. The plan targets to distribute 4 million improved biomass (charcoal and wood) stoves by 2022. The stoves were equally distributed both in rural and urban households. The scenario also looked at the gradual transformation in the charcoal conversion technologies under the transformation branch. Efficient charcoal conversion kilns shall increase gradually from 10% in 2015 to 50% in 2030. Electricity transmission and distribution losses were envisaged to drop from 18% in 2015, to 14% in 2022 and further to 8% in 2030. The three sub-scenario models were created under this main scenario. Details of the changing percent share of technology use is illustrated in tables 1 and 2.

i. *Improved charcoal conversion*
ii. *Increased adoption of modern and improved cookstoves and*
iii. *Reduced charcoal transportation losses*

C. Energy Transition scenario

This scenario sort to model transition from solid biomass to LPG. The NCCAP targets to disseminate 2 million non-solid fuels (LPG, ethanol and other cleaner fuels). However, considering established LPG distribution network, the target was entirely modelled for LPG distribution. Fuel stacking was considered such that only proportion of the households using charcoal alone shall be completely replaced. Others who will be using LPG shall continue using charcoal and wood to some proportions. Other actions that could be modelled in the future is the adoption of 6500 bio-digesters.

D. Combined Scenario

In this scenario we combined improved energy efficiency and fuel transitions scenarios. This also adopts the four sub scenarios including: Improved charcoal conversion, increased adoption of modern and improved cookstoves, reduced charcoal transportation losses and LPG dissemination. The scenario inputs are as in table 1 and 2 and shaded cells showing changes in fuel shares based on the adoption of various fuels and technologies.

Table 1. Improved Energy Efficiency scenario - model inputs

Energy Efficiency Scenario	**BAU**	**Efficient stoves distribution**		
Urban Cooking (% Share of household using fuel)	2015	2015	2022	2030
Firewood stoves				

Fan Assisted Biomass Stove	-	-	-	-
Improved Biomass Stove with Chimney	14.4	14.4	100.0	100.0
Traditional Stove Wood	85.6	85.6	-	-
Charcoal				
Modern Charcoal stoves	2.0	2.0	2.0	2.0
Kenya Ceramic Jiko	41.7	41.7	55.0	80.0
Traditional Stove Charcoal	56.3	56.3	43.0	18.0
Rural Cooking (% share of Households using fuel)	2015	2015	2022	2030
Firewood stoves				
Fan Assisted Biomass Stove	-	-	-	-
Improved Biomass Stove with Chimney	15.0	15.0	35.0	58.0
Traditional Stove Wood	85.0	85.0	65.0	42.0
Charcoal Stoves				
Modern Charcoal Stoves	0.4	0.4	0.4	0.4
Kenya Ceramic Jiko	39.0	39.0	45.0	58.0
Traditional Stove Charcoal	60.6	60.6	54.6	41.6

Table 2 Energy Transition - model inputs

Energy Transition Scenario	**BAU**	**Transition to LPG**		
Urban Cooking (% Saturation of Households)	2015	2015	2022	2030
Other fossil fuel	0.1	0.1	0.1	0.1
Briquettes and Pellets	2.0	2.0	2.0	2.0
Kerosene	29.5	29.5	29.5	29.5
Biogas	0.3	0.3	0.3	0.3
Electricity	2.0	2.0	2.0	2.0
Twigs and agri-residue	0.7	0.7	0.7	0.7
LPG	27.7	27.7	41.0	70.0
Charcoal	82.0	82.0	75.0	60.0
Firewood	7.0	7.0	3.5	2.0
Rural Cooking (% Saturation of Households)				
Other fossil fuel	0.1	0.1	0.1	0.1
Kerosene	2.3	2.3	2.3	2.3
Biogas	0.2	0.2	0.2	0.2
Electricity	0.3	0.3	0.3	0.3
Twigs and Agri residue and none-stated	1.5	1.5	1.5	1.5
LPG	2.5	2.5	13.0	39.0
Charcoal	8.9	8.9	4.9	2.5
Firewood	84.3	84.3	77.6	70.0

The scenario percentages were derived through calculation steps involving assessing current percent adoption and increased adoption in the future against the projected target year population. For instance, 60% of the distributed LPG (2million LPG stoves[1]) shall be adopted in urban areas and 40% in rural areas. This follows a campaign for rapid elimination of charcoal dependency in urban households. Thus, about 2.5 million more households in urban shall be using LPG above the current 1.2million translating to 41% adoption in 2022. In an ambitious progression, the 2022 adoption rates shall be doubled to slightly above 5million households using LPG translating to 70% of total urban population. This argument was followed for the targeted adoption of improved cookstoves in rural and urban areas.

Besides increased share of adoption of clean cooking solution, charcoal conversion technologies efficiency is expected to increase to about 25% in 2022 and 50% in 2030. This process shall be necessitated by increasing implementation of forest and energy policies through devolved government.

- Include screenshots of model runs and explanations under each image.

Upon implementation of NCCAP strategies, final energy demand is expected to reduce. As shown in figures1 a and bbelow about 7%, 21% and 26% of final energy shall be saved from the baseline in deploying energy efficiency measure, transition to LPG and combined efficiency and transition scenarios respectively. Final demand shall decrease from 609 million gigajoules to 450 million gigajoules if all the proposed interventions are implemented(Figure 1c)

[1] The 2 million LPG stoves mentioned in NCCAP

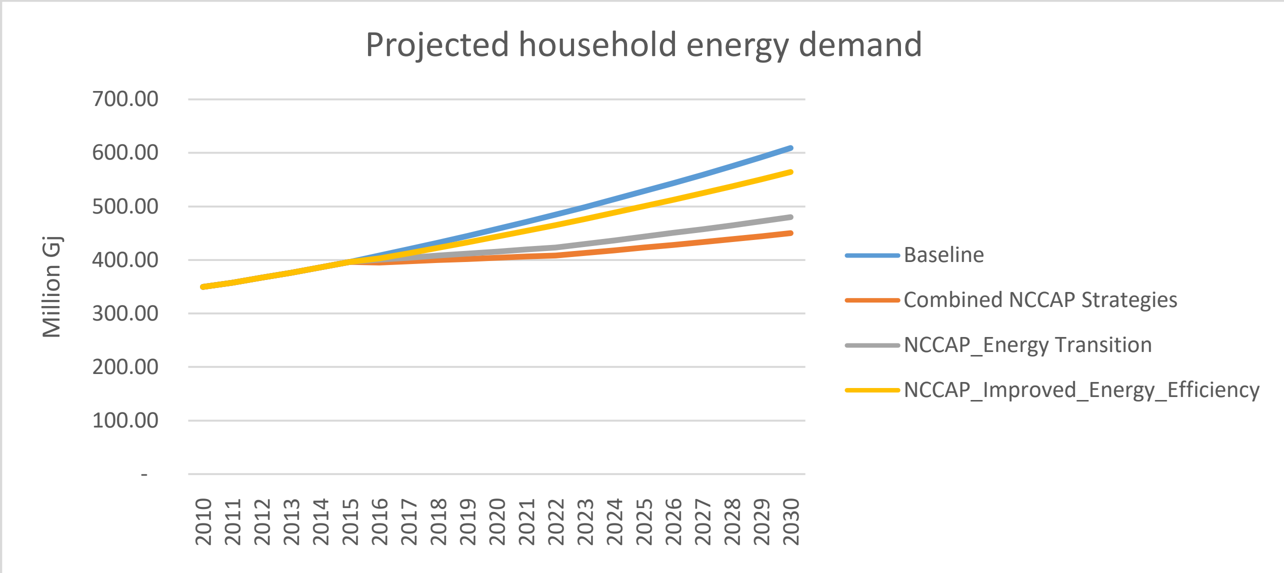


Figure 1 (a). Household energy demand in all scenarios

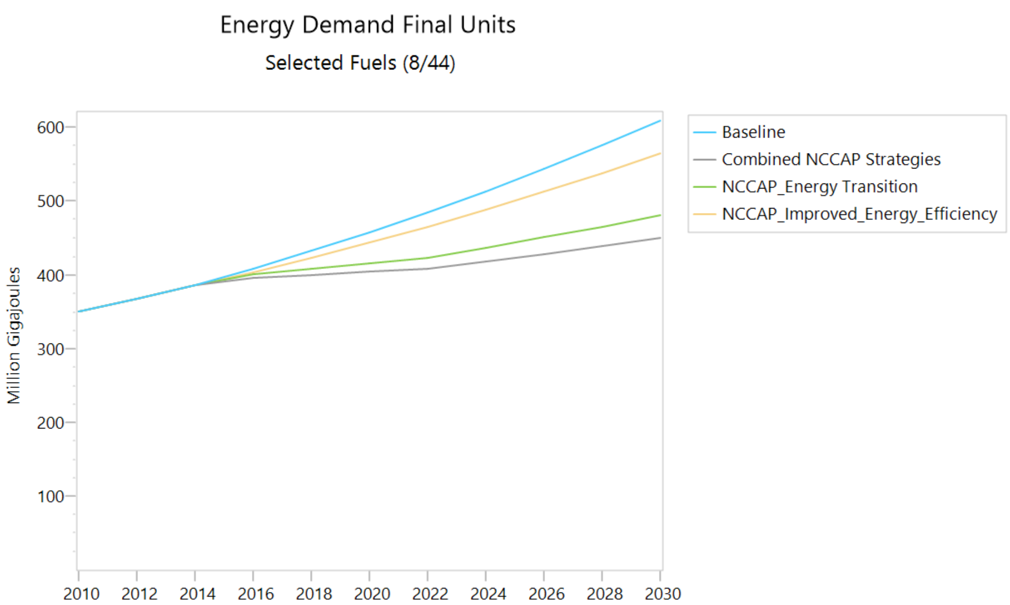


Figure 1(b). Household energy demand in all scenarios (screenshot)

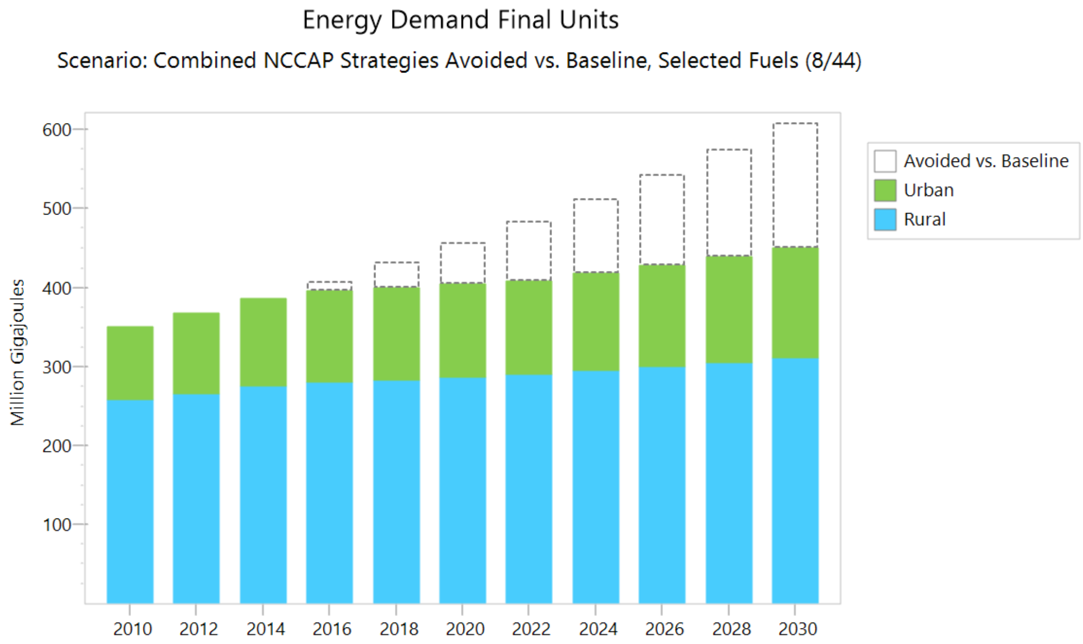


Figure 1(c). Energy demand avoided Vs Baseline(screenshot): Final demand shall decrease from 609 million gigajoules to 450 million gigajoules if all the proposed interventions are implemented.

Whereas charcoal shall substantially decrease in the urban residential energy demand as household adopt use of LPG and Kerosene wood remains a major source of energy in rural areas. In 2030, use of solid biomass (wood and charcoal) shall have reduced from about 72% in 2010 to 31% in 2030, whereas in rural areas, the change is very minimal from about 96% firewood and charcoal contribution to final energy demand 88% in 2030 in the combined scenario (Figure 4). As such, strategic action focusing on firewood in rural household is critical.

2.1.1 Charcoal and firewood demand in NCCAP scenarios

From figure 2 and table 3 below, firewood demand shall reduce to 21.9 million ton by implementing improved cookstoves initiative and 19.6 million tons by distribution of LPG as per the NCCAP targets. Combining these efforts would result to a demand of 17.7 million ton of firewood in 2030, thus saving 6.8 million tons of firewood. Similarly, in charcoal demand there is more benefits in implementing transition to LPG as compared to improved biomass stove strategy. A combined interventions scenario result to 2.9million tons of charcoal saving (equivalent to 19.5 million tons of wood). By 2024, more wood will be required to generate charcoal in the business and usual scenario (figure 3). This could be attributed to the rising urban population compared to rural population. However, in the combined strategy a reduction in wood requirement for charcoal production would be realised.

		2015	2022	2030
Wood demand Thousands of tons	BAU	17,255.40	20,342.63	24,520.80
	Energy Eff	17,255.40	19,174.09	21,947.55
	Transition	17,255.40	18,281.33	19,560.82
	Combined	17,255.40	17,364.51	17,714.97
		2015	**2022**	**2030**
Charcoal demand Thousands of tons	BAU	2,543.24	3,242.89	4,332.89
	Energy Eff	2,543.24	3,188.80	4,151.15
	Transition	2,543.24	1,973.89	1,474.07
	Combined	2,543.24	1,947.82	1,415.86

Table 3: Wood and Charcoal demand all scenarios.

Figure 2. Wood and charcoal demand in all scenarios

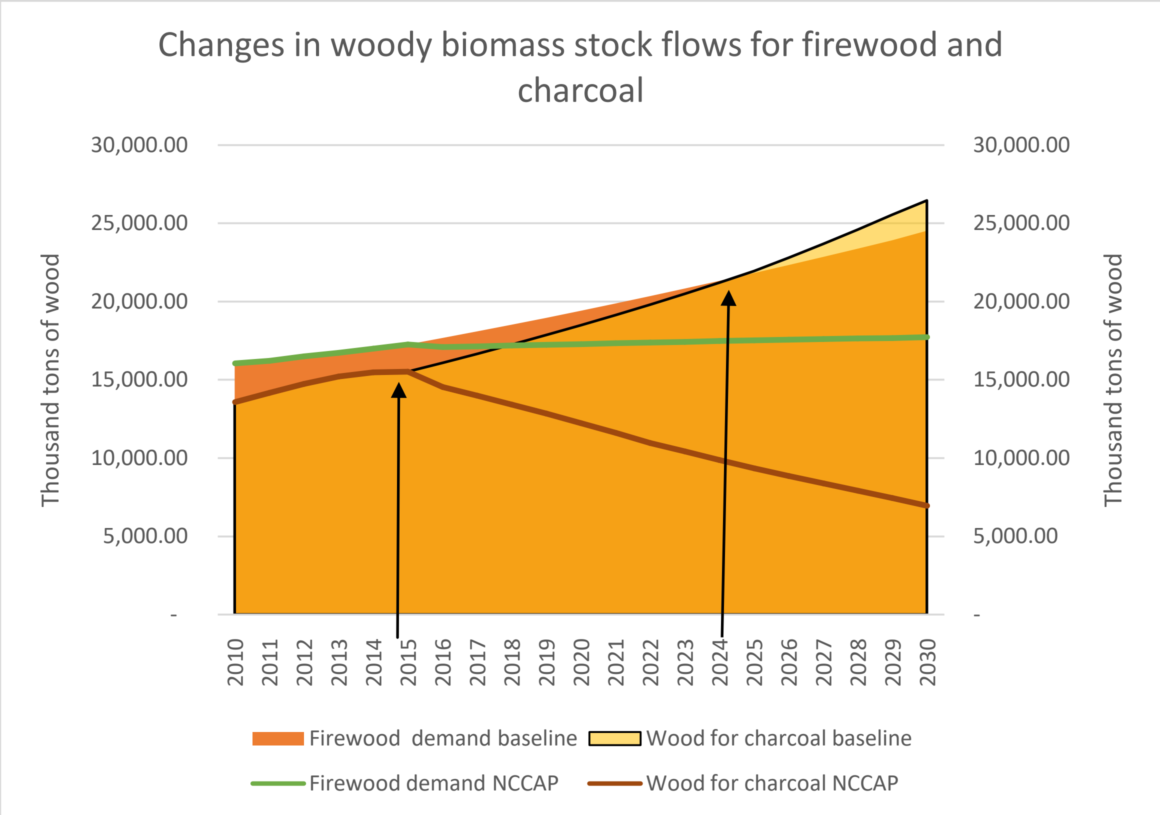


Figure 3. Wood requirement to meet charcoal and firewood demand

Table 4 below illustrates total woody biomass harvested in the baseline and combined scenarios. In 2022, 40 million tons of firewood will be harvested and 50.9 million tons in 2030 in the business as usual scenario. However, when the NCCAP combined intervention if implemented results to a reduction of 11.8 million tons of wood biomass in 2022 and 26 million tons in 2030.

Table 4 Biomass fuel use

	Demand in '000' tons	**2022**	**2030**
Baseline	Charcoal	3,242.89	4,332.89
	Firewood	20,342.63	24,520.80
	Wood for Charcoal	19,795.25	26,454.02
	Total wood stock harvested	***40,137.87***	***50,974.82***
NCCAP Scenario	Charcoal	1,947.82	1,415.86
	Firewood	17,364.51	17,714.97
	Wood for Charcoal	10,964.35	6,943.54
	Total wood stock harvested	***28,328.86***	***24,658.51***
Avoided	Total charcoal	1,295.07	2,917.03
	Total firewood	2,978.12	6,805.83
	Total wood Avoided	**11,809.02**	**26,316.31**

2.1.2 LPG demand and supply in the transition scenario 2022 and 2030

As aforementioned, there is observed steady growth of LPG adoption in the baseline and NCCAP scenario. There is a move by the government to subsidized cylinders to promote the uptake of LPG as a fuel and reduce the use of kerosene and charcoal. In the NCCAP scenario, we modelled increased adoption of LPG by 1.2 million stoves in urban areas and 0.8 million in rural areas by 2022. As such it was observed that, LPG imports shall increase to 334,000 tons in 2022 in the NCCAP scenario strategy against 184,000 tons in the business as usual. This will thus mean more national expenditure on petroleum products (table 5)

Table 5. LPG demand in business as usual and mitigation scenario

Demand in '000' Tons	*2010*	*2018*	*2022*	*2030*
Baseline	59	158	184	249
Combined NCCAP Strategies	59	214	334	890

2.1.3 NCCAP mitigation impacts of the selected targeted solutions

Upon implementation of the above strategies, there will be environmental and socioeconomic benefits such as GHG abatement, improved health, reduced crop loss and employment creation. In this section we discuss some of the environmental and socioeconomic benefits of the proposed NCCAP interventions.

GHG abatement

The mitigation action shall result to about 2.6 million tCO2 equivalent and 7million tCO2 equivalent reduction in 2022 and 2030 respectively in the combined mitigation strategies. (Figure 4). This shall help move the country forward towards achieving its NDC. In the energy demand, the NCCAP target to reduce 6.09 $MtCO_2$ by 2030.

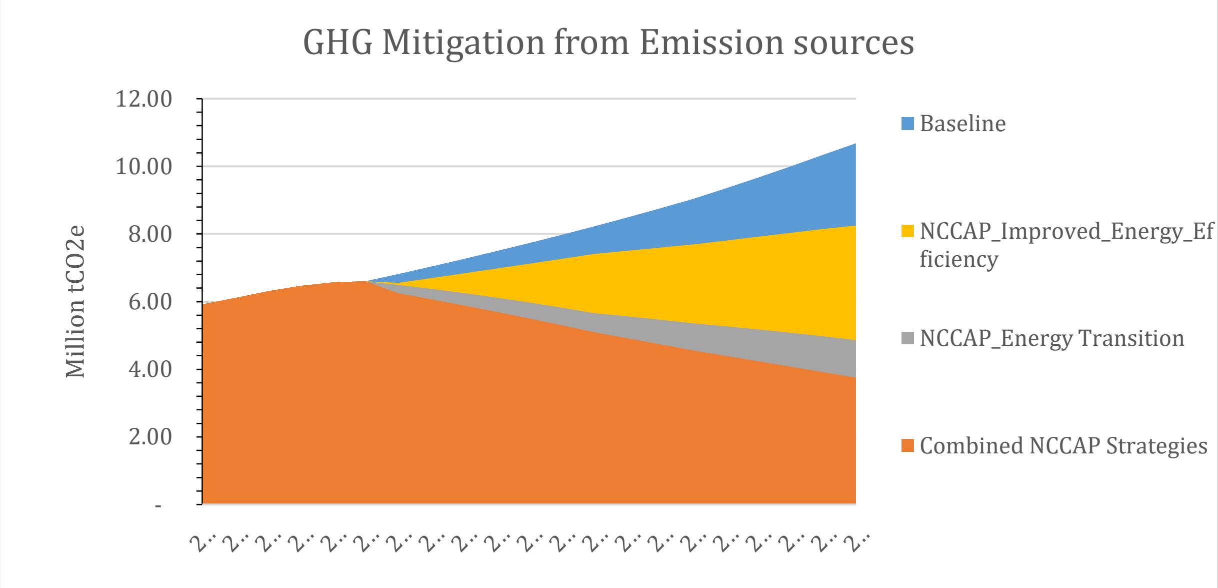


Figure 4: GHG mitigation scenarios

Family income

Reducing household fuel expenditure as a result of increased adoption of efficient cookstoves. Adoption of Kenya ceramic jiko reduce fuel use by 10% and other modern stoves on average would reduce expenditure by 23%. In a typical household annual charcoal consumption of 594 kg equivalent to 17 bags of charcoal annually a saving of 1.7 bags per year per family realizing Kshs. 3,500 annually. From the modelling results a possible saving of 2.9 million tons of charcoal could be achieved in 2030. Translating this into cost, the nation will save 165 billion Kenya shillings saving by 2030.

Employment

Implementation of the strategies is a two-sided coin. Theoretically there will be both loss and creation of job. It is estimated that the charcoal sector supports the livelihoods of 2-2.5 million Kenyans directly and indirectly, creating employment for 0.5-0.7 million as producers (farmers and burners), traders/middle men and vendors across the value chain (NAMA, report). In the NCCAP scenario and assuming direct proportionality in reduced charcoal trade, 67% of jobs in the charcoal value chain shall be lost. Thus between 0.33 – 0.47 million jobs shall be lost. However, growing the LPG value chain by about 350% will provide alternative value chain and more jobs created in improved cook stoves scenario.

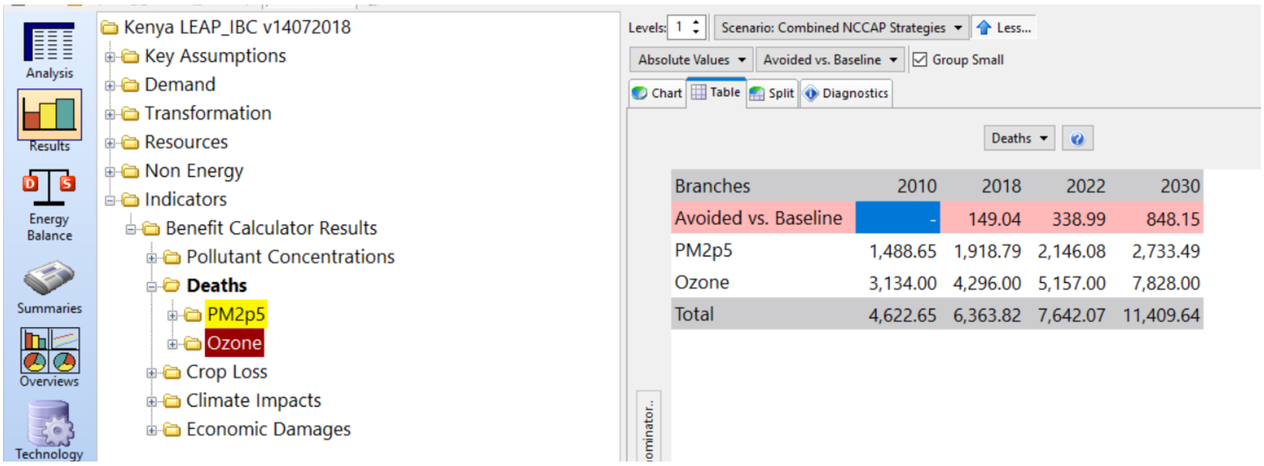
Health and livelihood

The effect of human health burden because of ambient air pollution was also modelled. It is estimated that ambient air pollution caused about 4.2million deaths in 2016(WHO, 2018). About 7% were children below 15years exposed to unclean ambient air. Reports indicate that particulate matter ($PM_{2.5}$ and PM_{10}) causes more premature deaths than any emissions. In developing countries, residential sector is the main contributor to $PM_{2.5}$. WHO statistics 2018 reports that about 34thousand Kenyans died in 2016 due to ambient and indoor air pollution(World Health Organization, 2018). Inspite of these health burden due to air quality, there is a major data gap in developing countries such as Kenya to inform policy and strategies.

In Kenya, residential sector alone contributes to 190,000 tons of PM 2.5 and 41,000 tons of black carbon released to the atmosphere. The health burden associated with these emissions result to premature deaths and mostly affected are elderly generation over 50 years and children below the ages of 5 years. Ozone particularly affect mainly the youthful population of above 30 years. The limited action of reducing dependency on solid biomass for cooking would result to annual prevention of about 337 deaths annually in 2022 and 848 deaths in 2030 (table 6 and figures 5 a & b).

	2010	2018	2022	2030
PM2p5	1,489	2,034	2,419	3,424
Ozone	3,137	4,314	5,202	7,957
Total	4,626	6,348	7,621	11,381
Avoided Premature Deaths through Mitigation actions	-	*149*	*337*	*848*

Table 6: Avoided deaths by reducing dependency on firewood and charcoal



Branches	2010	2018	2022	2030
Avoided vs. Baseline	-	149.04	338.99	848.15
PM2p5	1,488.65	1,918.79	2,146.08	2,733.49
Ozone	3,134.00	4,296.00	5,157.00	7,828.00
Total	4,622.65	6,363.82	7,642.07	11,409.64

Figure 5a: Avoided vs Baseline scenario for Black Carbon and Ozone

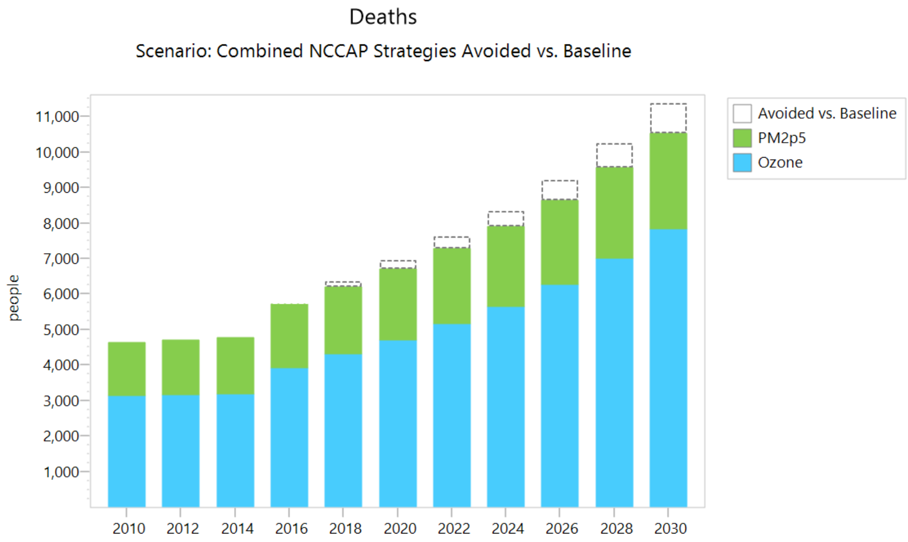


Figure 5b: Avoided vs Baseline scenario for Black Carbon and Ozone

Other benefits of mitigation action

Ozone gas is formed through an atmospheric reaction between different emission gases and UV radiation. LEAP – IBC tools computation indicated that we shall losses close to 52 Thousand metric tons of produce due to Ozone in 2022 and about 85 thousand metric tons of produce (Maize, soy, rice and wheat) due to national ambient air quality. The few mitigation scenarios modelled in the residential sector shall yield to a saving of close to 6 thousand tons of these agricultural produce that could have been lost.

In reducing the transmission and distribution technical losses from current 18% to 14% in 2022 and further 8% in 2030, it was observed that about 700 GWh in 2022 and 2,500 GWh in 2030.

Translating this to domestic connections in the current average electricity consumption intensity of450 kWh/household-year, about 1.5 million new connections would be achieved in 2022 and 5.6 million households in 2030 at no extra cost.

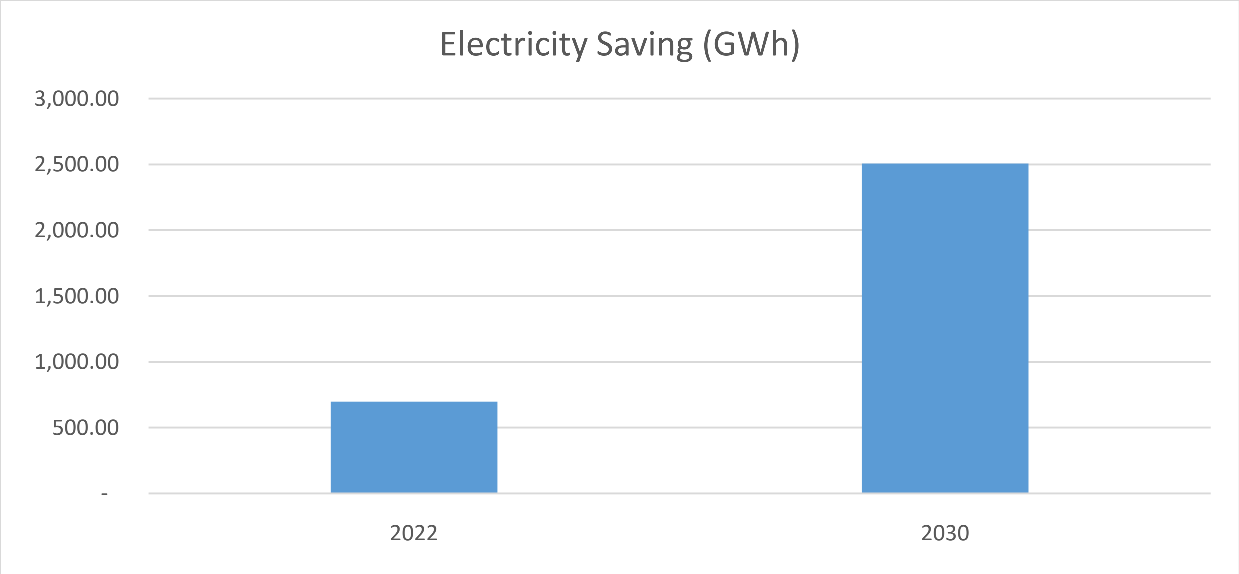


Figure 6: reducing the transmission and distribution technical losses from current 18% to 14% in 2022 and further 8% in 2030.

2.1.4 SUMMARY ON LEAP MODELING

The Kenya **LEAP model** has shown that it is possible to forecast climate and socio-economic benefits of adoption of clean cooking solutions (carbon mitigated, forest sinks preserved enhanced jobs created, increases, cost savings).

2.2 I-JEDI MODELLING RESULTS-UPSCALING LPG USE

An Attempt was done to model up-scaling the use of LPG and the associated the social and economic benefits using I-JEDI, (**International Jobs & Economic Development Impacts I-JEDI model).** The government has started promoting Liquefied Petroleum Gas (LPG) in Kenya, using Kajiado County as a pilot.The program target is 10,000 households; the cost of cylinders is Ksh 4,000. The cost of transportation is Ksh 200 per cylinder. The total expenditure for the LPG is hence Ksh 420,000.The charcoal consumption currently is estimated at Ksh 21,600 per household per year. The total expenditure is Ksh 2.16 Million for all the 10,000 households.

Key assumptions agreed by the team was that- even if households adopt LPG, there will still 50% usage of charcoal. So, the decline in use of charcoal is 50 %(1.08Million).

The one-time expenditure and the ongoing expenditures all are made within Kenya. This includes purchase of LPG and transportation.

The following table shows the Direct, Indirect and Induced Impacts:-

- **Direct** – Direct project development expenditures
- **Indirect** – Spinoff economic activity & supply chain effects
- **Induced** – Expenditures by direct & indirect workers

One-time impacts-Initial phase Moving from firewood/charcoal stove to clean cooking in Kajiado County

	Output	Value Added (on GDP)	Earnings
Direct	$420,000	$109,113	$26,537
Indirect	$890,162	$231,640	$62,456
Induced	-$181,006	-$87,263	-$54,180
Total	**$1,129,156**	**$253,490**	**$34,814**

Table 7: Cost-Moving from firewood to LPG clean cooking solution

Impacts-during operation and maintenance phase moving from firewood/charcoal stove to clean cooking in Kajiado County

	Output	Value Added (on GDP)	Earnings
Direct	$ 160,000	$ 282,233	$ 67,516
Indirect	$ (216,935)	$ (291,031)	$ (71,332)
Induced	$ (1,216,505)	$ 126,770	$ (29,329)
Total	**$ (1,273,440)**	**$ 117,971**	**$ (33,145)**

Table 8: Cost during Operations –LPG up scaling.

- **Earnings** – Aggregate of all compensation for work
- **output** – Measure of overall economic activity
- **GDP** (value added) – Value of industry’s production

2.3 BUILDING MITIGATION SCENARIOS IN AGROFORESTRY

Agro forestry is a land-use system that involves deliberate retention, introduction, or mixture of trees or other woody perennials in crop and animal production systems to take advantage of economic or ecological interactions among the components. In Kenya agroforestry can be broadly classified as silvopastrol and agrosilvicultural which is the practice of integrating trees and livestock production and cropland with tree components respectively.

Cropland includes all annual and perennial crops as well as temporary fallow land (i.e., land set at rest for one or several years before being cultivated again). Annual crops include cereals, oils seeds, vegetables, root crops and forages. Perennial crops include trees and shrubs, in combination with herbaceous crops (e.g. agroforestry) and plantations such as coffee, tea, coconut and bananas except where these lands meet the criteria for categorization as Forest land. In 2009, the government enacted regulations (Farm Forestry Rules, 2009) aimed at increasing tree components in cropland and this directly impacts on agroforestry practice in Kenya.

Similarly National Climate Change Action Plan (NCCAP) 2018-2022 has identified agroforestry as a climate change mitigation and adaptation actions. This study used the area, carbon stocks and Net Present Value (NPV) for the land use classes to model the opportunity cost and climate related benefits for three scenarios of agroforestry in Kenya i.e historical(baseline),implementation of farm forestry rules 2009 and NCCAP 2018-2022.The results and discussions of these scenarios are as shown below:

2.3.1 Policy intervention in agro-forestry implementation of forestry rules (OPTION 1)

I. Implementation of farm forestry rules 2009

This policy interventions seeks to increase tree cover to at least 10% in every farm in Kenya .The net effect of this policy direction is 10% increase of trees in agroforestry, silvopastrol, open grassland and all agricultural land uses.

II. Agroforestry Interventions in Nation Climate Change Action Plan(NCCAP 2018-2022)

NCCAP 2018-2022 aims to further Kenya's development goals by providing mechanisms and measures to achieve low carbon climate resilient development. The proposed actions of achieving this goals includes deployment of agroforestry technologies and restoration of degraded lands .This interventions are expected to enhance carbon sequestration and increase landscape resilience to climate change through increasing the area under agroforestry by 600,000 ha.

The results indicates there will steady increase of emission across the three model scenarios (Baseline, Farm Forestry rules 2009 and NCCAP 2018-2022). Projection of baseline emissions to 2044 (next 30 years) are expected to increase from 643M, tons to 1852Mtonsas shown in Table 9. Projection of the baseline emissions to 2044 are used as the baseline case against which it is possible to demonstrate the expected abatement potential for each of the policy interventions. The composite mitigation abatement mitigation potential of the low carbon development opportunities show that the largest mitigation potential is by the implementing the farm forest rules 2009 that will abate 434M tons of carbon dioxide by 2044 followed by implementation of NCCAP that has abatement potential of 297M tons (Table 9 and Figure 7).

Table 9: Projection of emissions based on historical data and abatement potential based on policy interventions

Periods	Historical(ton CO_2-eq)	Implementation of Farm Forestry rules 2009(ton CO_2-eq)	NCCAP 2018-2022(ton CO_2-eq)	Abatement Potential farm forestry rules(ton CO_2-eq)	Abatement potential NCCAP(ton CO_2-eq)
[0] 0-5	643,227,733	643,227,733	643,227,733	0.00	0.00
[1] 5-10	1,062,695,995	832,482,846	881,136,076	230,213,149	181,559,919
[2] 10-15	1,352,261,211	1,002,812,447	1,085,584,612	349,448,763	266,676,598
[3] 15-20	1,563,284,188	1,156,109,089	1,263,256,040	407,175,099	300,028,147
[4] 20-25	1,724,440,005	1,294,076,066	1,418,524,084	430,363,938	305,915,920
[5] 25-30	1,852,164,217	1,418,246,345	1,554,595,776	433,917,871	297,568,440

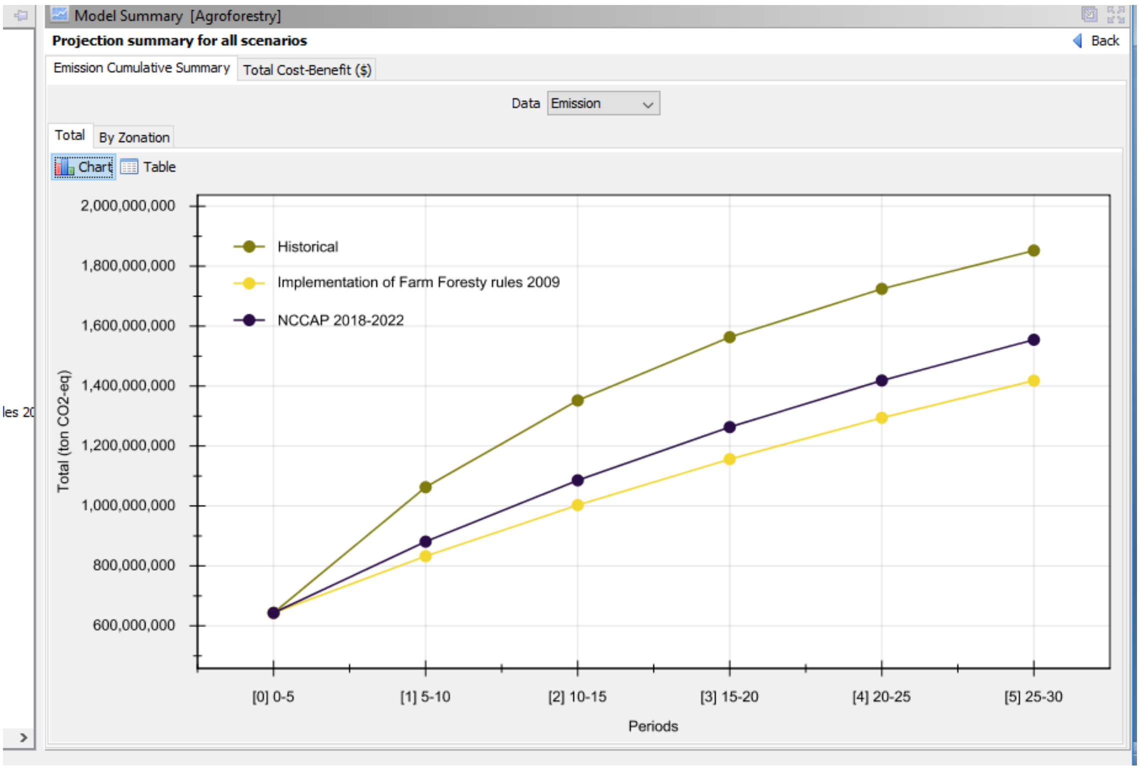


Figure 7: Emissions reductions scenarios, Farm forestry rules implementation has the highest abatement potential

TOTAL COST BENEFIT OF FARM FORESTRY

Cost- Benefit analysis show that Implementation of Farm Forestry rules 2009 will result to a total of approximately **9.6 Billion USD** in the next 30 years (Figure 8 and table 10).

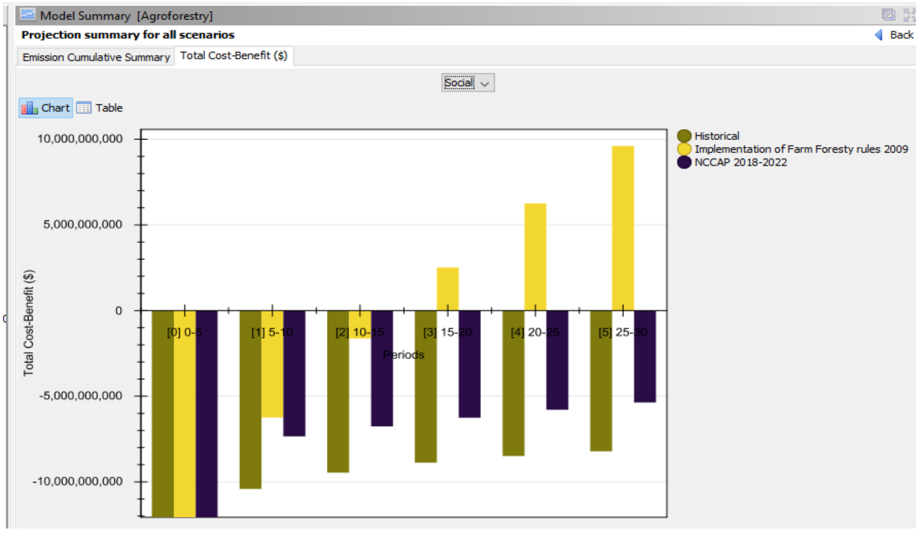


Figure 8: Comparison of cost benefit of the interventions scenarios versus the baseline scenario

Projection summary for all scenarios

Emission Cumulative Summary | Total Cost-Benefit ($)

Social

Chart | Table

	Periods	Historical	Implementation of ...	NCCAP 2018-2022
1	[0] 0-5	-12,066,636,726	-12,066,636,726	-12,066,636,726
2	[1] 5-10	-10,409,218,391	-6,241,411,964	-7,342,804,449
3	[2] 10-15	-9,459,678,421	-1,630,763,890	-6,763,251,271
4	[3] 15-20	-8,878,039,023	2,518,819,376	-6,253,660,691
5	[4] 20-25	-8,493,907,170	6,253,444,315	-5,792,724,578
6	[5] 25-30	-8,220,858,572	9,614,606,761	-5,370,094,766

Table 10: Cost- Benefit analysis show that Implementation of Farm Forestry rules 2009 will

result to a total of approximately 9.6 Billion USD in the next 30 years

2.3.2 Policy intervention in agro-forestry- reducing slash and burn practice (OPTION 2)

We modeled opportunity cost for agro forestry options as compared to slash and burn practices for the period 2000- 2014 using data generated by Agricultural Sector Development Strategy 2010-2020,NDC sector analysis,System for Land based Emission Estimation in Kenya (SLEEK) and Forest and Landscape Restoration (FLR) projects in Kenya. The study showed Kenya has a potential area of **5, 854 613ha** whereagriculture practices for agroforestry, slash- burn and residue burning is practiced (table 11).

	Zone	Area (ha)
1	SLASH AND BURN	2,873,000
2	AGROFORESTRY (LESS10%)	542,686
3	RESIDUE BURNING IN AGRICULTURE	2,438,950
	TOTAL	**5,854,636**

Table 11: Area of land uses in Kenya

Table 12 below documents the level of carbon stocks based on studies (Nair, 2013 and Kuyah et al, 2012)coupled with expert knowledge. This values were used in modeling the opportunity cost of implementing the 3 practices in Kenya.

	LAND USE TYPE	Tons/ ha
1	SLASH AND BURN	**0**
2	AGROFORESTRY (LESS10%)	**41**
3	RESIDUE BURNING IN AGRICULTURE	**10**

Table 12: Level of carbon stocks of land use in Kenya

Net Present Value in Kenya

Net present value (NPV) or sometimes called present value, is a calculation commonly used to estimate the profitability of a land use over many years. NPV takes into account the time-value of money. Since waiting for profits is less desirable than obtaining profits now, the “value” of future profits is discounted by a specific percentage rate (White et al. 2010).Agroforestry land use systems in Kenya involving perennials crops and livestock production constitute long term investment. A number of studies (KSIF 2017-2027,Lager and Nyburg,2016,Quandt et al, 2017, Asena et al, 2017, Mugure and Oino 2013) have valued the contribution of agroforestry in terms of profitability, NPV and climate benefits. The REDD Abacus have utilized NPV figures (Table 13) as documented by the above researches in the estimation of opportunity cost for various agricultural practices / options.

	LAND USE TYPE	$/ ha
1	SLASH AND BURN	**9**
2	AGROFORESTRY(LESS10%)	**132.5**
3	RESIDUE BURNING IN AGRICULTURE	**35**

Table 13: NPV values of land use in Kenya

Policy interventions: Increase tree cover by 10% in slash-burn and residue burning areas

The policy intervention seeks to increase tree cover to at least 10% in agricultural land that are currently undergoing slash and burn agricultural practices.The mitigation scenarios to reduce GHG emissions based on historical emission baseline wasperformed using REDD Abacus. Scenarios used in this studyreflect possible emission reduction interventions in agriculture sector as envisioned in the Agricultural Sector Development Strategy 2010-2020 and Kenya's Second national communication. Thecurrent trend is reflected in the Business as Usual (BAU) scenario where there is noimplementation of a good practices of agriculture as in smallholder slash-and-burn farm holdersThe modeled results shows the climate and opportunity cost of this interventionif fully implemented. The emission will reduce from **132 million** tonnes to **95 million** tonnes in a period of 30 years(table 14 and figure 9).

	Periods	Historical	10% tree cover abatement potential
1	[0] 0-5	132,009,628.67	132,009,628.67
2	[1] 5-10	132,009,628.67	123,066,812.00
3	[2] 10-15	132,009,628.67	115,018,277.00
4	[3] 15-20	132,009,628.67	107,774,595.50
5	[4] 20-25	132,009,628.67	101,255,282.15
6	[5] 25-30	132,009,628.67	95,387,900.13

Table 14: Emission reductions for the agroforestry Interventionas compared to BAU

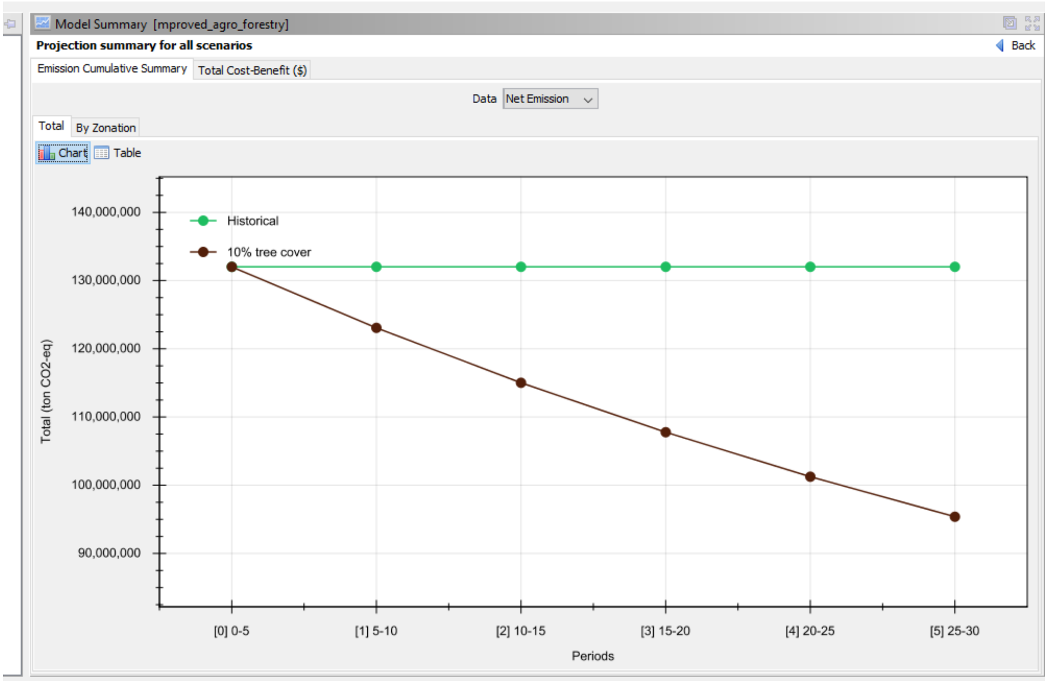


Figure 9: Emission projection for agro-forestry scenario as compared to BAU l scenarios

Figure 10 and table 15 illustrate the total cost –benefits of the agroforestry intervention as compared to BAU of slash and burn. The cost benefits will increase from about **16millio**n dollars to **24 million** in the first 5-10 years.

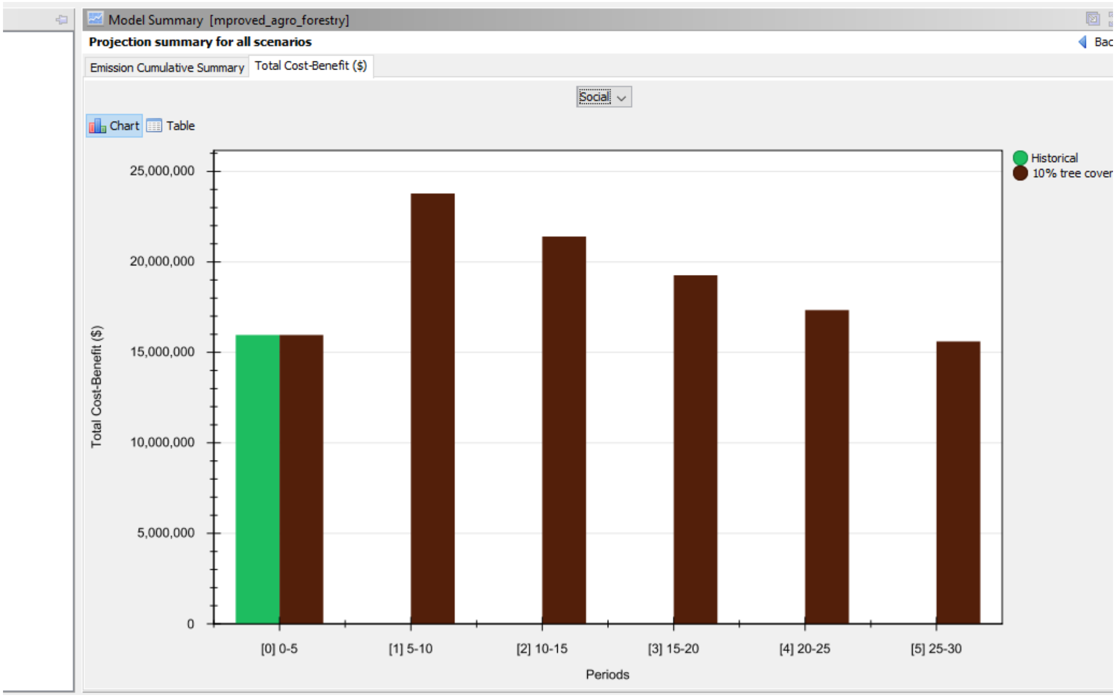


Figure 10: Total cost benefit (USD) Agro forestry intervention

	Periods	Historical	10% tree cover, total cost benefit $
1	[0] 0-5	15,958,979	15,958,979
2	[1] 5-10	0	23,779,762.50
3	[2] 10-15	0	21,401,786.25
4	[3] 15-20	0	19,261,607.63
5	[4] 20-25	0	17,335,446.86
6	[5] 25-30	0	15,601,902.18

Table 15: Total Cost benefit of Agro forestry as compared to slush and burn practice.

2.4 Summary on ABACUS

Based on the historical analysis and modelling Agro-forestry the following conclusion can be drawn:

- The land use changes in Kenya are impacting on GHG levels
- If interventions are not implemented the emission have a negative economic impacts
- The proposed policy interventions(Farm Forestry and NCCAP) have a mitigating effect on emissions
- Farm Forestry intervention implementation have highmitigating potential by 2030 and associated socio-economic benefits.

3. CHALLENGES AND GAPS

- One of the gaps reported across the clean cooking solutions and agroforestry was unavailability of accurate data especially on agro-forestry modeling.
- Forecasting and modelling the total valuation of forestry ecosystem & socio- economic benefits (jobs created, % GDP increase, income increasesand cost savings) still remains a challenge. This is compounded by lack of local experts on modeling socio-economic agro-forestry using ABACUS software. It was anticipated that NREL will provide external experts to spearhead capacity building in Agro-forestry aspects, but this did not happen. The team attempted to use their limited skills and hope that NREL and other external experts may help add value.
- Policy taskforce formation may be beyond the mandate of the technical modelling team.

4. CONCLUSION & WAY FORWARD

- Significant progress was made in modelling clean cooking solutions. However there is little local expertize to support modelling of agro-forestry .Modelling Agro forestry in general will require external experts since our attempt to share our models with the Mozambique team and NREL have not yielded the desired results.

- **The following need to be completed as per the original budget**

No.	Activity Item	Budget USD
2.1	Adapt and test above model options relevant to long term LEDs planning in line with Kenya`s economic priorirties (partly done).	8000
2.2	Calibrate, transfer and installation of relevant software and hardware technologies of adopted models(s) in decision frame works of technical and policy departments in relevant line Ministries	8000

LEDS STATEMENT- record on video

1. The overall objective of the project was to assist Kenya establish requisite modelling & analytical capacity to inform concrete LEDS policies and plans and their implementation for prioritized low emission, climate-resilient, and resource efficient socio-economic development consistent with Nationally Determined Contribution (NDCs) & other LEDS plans.

2. A Kenya LEDs modelling team was established and two priority sectors selected based on the emissions levels. Forestry and energy sector were the prioritized sectors.

3. In the energy sector modelling was focused on clean cooking solutions as it would create a huge impact in terms of emission reduction, health and poverty reduction. While in the Forestry sector, priority was given to modelling agro-forestry as one of the priority options in restoration of forests.

4. In Kenya, as it is in many developing counties, quantifying the cumulative climate (e.g. carbon mitigated) & socio-economic (jobs created, % GDP increase, income increases, cost savings) is still new and has not been taken up in development planning. In addition, the skills and expertise in modelling socio-economic outcomes/impacts is mostly lacking. But through this project, the team held more than 6 workshops and more than 10 officers were significantly trained in climate change mitigation options and related socio-economic benefits. However, actual socio-benefit monitoring will be achieved once the NDC are implemented, which require significant investment from GOVERNMENT and DEVELOPMENT PARTNERS.

5. I thank our Partners (EC & UNEP) for the support and look forward to full uptake of this project products going forward.

Charles Mutai, PhD
UNFCCC NFP.

"Climate action and socioeconomic development seem to be difficult to achieve simultaneously – but through this project, Kenya is set to leverage implementation of its NDCs as an enabler of its socioeconomic priorities – the vision 2030 and its derivatives like the BIG 4. This will be highly valuable as we prepare to submit second round NDC commitments – we thank the EC & UNEP for their support and look forward to full uptake of this project products going forward"

Augustine Kenduiwo
Ministry of Environment and Forestry

ANNEX B.

Component 2 modelling team

The Low Emissions Development Strategies (LEDS) Modeling Team Kenya-

List from which modeling participants is drawn from.

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