Resource requirements report for Belize's NDC

Report prepared for the Belize National Climate Change Office under the Climate Action Enhancement Programme

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Contents

Acknolwedgements

Cover photo by Kevin Quischan.

1 Introduction

This report summarises the cost requirements for activities related to the delivery of targets included in Belize's updated NDC. Given the ongoing development process of the NDC, the activities costed in this report will need to be revisited to align to final targets set out in the NDC. The costs reported here are largely based on costs of delivering the projects. Additional resources may be required to develop capacity of the government agencies to oversee delivery. These feasibility costs are detailed further in an accompanying feasibility study report prepared by RMI. Costs presented in this report may include 'consumer costs' that are not expected to be borne by government or external support. Where possible to separate these costs, they are indicated as such.

Many different types of resources will require mobilisation in order to meet the NDC targets, however the main two covered in this report are financial and human resources. Financial resources, as outlined in Table 1, provide the assumed monetary values needed to meet the target. The final costings are based on certain assumptions or expert insights, which are discussed in each section. These also include a discussion of the funding that has already been mobilised and the funding gap, therefore how much of the total cost is left unfunded. The human resources, as discussed in section 4, estimate the time and expertise gaps present in Belize.

Table 1 summarises the cost estimates and funding requirements detailed in the report. The 'total cost estimate' reflects costs of delivering the set of actions identified in each sector, while the 'estimated funding requirements' represent the unfunded portion of these costs.

Table 1 Summary of estimated resources required to 2030

Sector	Total cost estimate *USD million*	Estimated funding gap *USD million*
Mitigation actions		
Land Use Change and Forestry	402	349
Agriculture	41	10
Energy	624	561
Waste Management	327	317
Subtotal (mitigation)	**1,394**	**1,237**
Adaptation actions		
Coastal and marine resources	35	12
Agriculture	113	72
Water resources	25	11
Tourism	36	17
Fisheries and aquaculture	13	1
Human health	13	8
Land use, human settlements and infrastructure	58	25

Sector	Total cost estimate *USD million*	Estimated funding gap *USD million*
Subtotal (adaptation)	318	146
Total	*1,712*	*1,383*

Source: Vivid Economics

Total resource requirements associated with updated NDC targets are estimated at USD$1,712 million. The funding gap is estimated at USD$1,383 million, however is expected to reduce to USD$607 million. This is because USD$776 million in renewable energy and waste service costs is expected to be recovered through fees from the users of these services. Useful comparisons for this number include:

- the National Climate Resilience Investment Plan (NCRIP), which estimates a USD$112.5 million financing requirement (in addition to a USD$348 million existing investment programme) to develop climate adaptation capacity in the country over the next 10 years.
- Priority needs totalling USD$376 million for public sector investments and USD$172 million in private sector investment as estimated by the IMF in its 2018 Climate Change Policy Assessment, in line with a total resource requirement of USD$548 million as set out in the existing NDC

The additional costs included in this estimate are driven by 1) a consideration of total system cost for a renewable energy-powered electricity grid and 2) implementation costs of the REDD+ strategy, including costs related to mangrove protection and restoration that were not considered in previous studies.

Costs related to electricity are likely to be recovered from the sale of electricity. The levelized cost of electricity for both solar and gas are comparable and incremental costs could be relatively minor. Likewise, the cost estimates for delivering the national waste target includes USD$200 million in collection costs, which could be reasonably recovered through municipal service fees.

This report presents discusses the resources needed to meet the targets of the NDC, split into mitigation and adaptation. The document is structured as follows:

- Section 2 discusses the climate mitigation costs, starting from a general overview and then exlporing each sector in turn, covering land use change and forestry, energy, agricultrue and waste management
- Section 3 details the climate adaptation costs, covering the following sectors: agricuture, coastal and marinee resources, fisheries and aquaculture, human heath, infrastructure, tourism and water sources
- Section 4 indicates the human resource requirements, identifying skill or expertise gaps

2 Climate mitigation costs

This section provides estimates of the total costs and financing gaps within the four sectors within which mitigation actions have been identified: (1) Land use change and forestry (LUCF), (2) Energy, (3) Agriculture and (4) Waste Management.

2.1 Mitigation target costing methodology

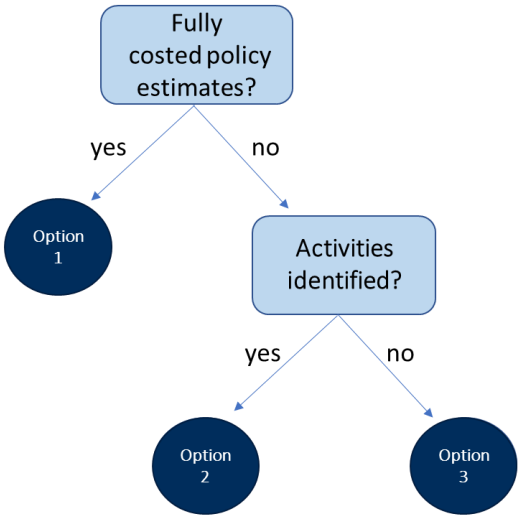
Mitigation targets are grouped into broad mitigation actions and the subsections of this document focus on estimating the cost of meeting all the targets within each of these actions. This approach was adopted since there is often significant overlap between targets (as they originate from various documents) and costing them all individually would have resulted in double counting in many cases. Where more than one target is included within a specific action, the costing is usually based on the most quantitative target(s), while qualitative targets are typically used to inform which types of activities will be undertaken to meet the quantitative targets. Where more than one quantitative target is associated with a particular action, we either cost these individually or estimate the total cost in a way that considers both targets. In cases where no quantitative target exists for an action we clearly specify how we have interpreted the intended scale of this target.

Within each action we also identified all relevant ongoing or proposed projects or interventions – which we jointly refer to as "activities". The focus of the costing exercise is therefore not only to determine the total cost of achieving the relevant targets, but specifically to estimate the financing gap that remains after these activities have been considered.

No single standardised methodology could be applied to all targets given the significant differences that exist between targets and sectors – in terms of factors like the level of target specificity, the target unit (e.g. emissions reduction or percentage of total) and the target duration. At a high level we followed the approach outlined in Figure 1, which includes three options:

- Option 1: Apply existing cost estimates from national policy documents/strategies and project documents shared during stakeholder engagement;
- Option 2: Where target partially delivered by costed activities, scale known costs of activities to meet target;
- Option 3: Apply cost estimates from a relevant international or local examples and adjust to Belize context.

Figure 1 NDC action costing approach



Source: Vivid Economics

In almost all cases for mitigation targets, existing activities with cost estimates were not considered sufficient to fully achieve relevant targets. We have therefore relied on some combination of options 2 and 3. To apply these methods in each case we followed four steps, which align to the way in which the presentation of mitigation cost estimates are structured:

1. Validate cost estimates for identified existing activities - this entailed determining:
    a. whether the existing cost estimate appears reasonable given the available information for this activity[1]
    b. what proportion of these costs should be allocated to the action/target being costed
    c. determining, as far as possible, what proportion of the overall target will be achieved by completing this activity. For example, if the target states a specific intended emissions reduction amount, we estimate how much of this reduction might be achieved through this activity.

2. Gap analysis: This step entails selecting between the three options listed in Figure 1. This typically involves identifying the range and scale of policies or activities that will need to be implemented to achieve this target.

3. Indicative costing: This step involves outlining the costing assumptions made and estimating the cost of meeting targets under different scenarios.

4. Action cost summary: This step involves determining the total cost and financing gap estimates. The main caveats or considerations for these estimates are also provided.

2.1.1 Potential limitations

Methodological limitations of the costs presented here should be considered. Additional feasibility analyses can identify more specific and disaggregated costs as are required in some cases. The costs of conducting

[1] This is typically done at a fairly high level given the lack of detailed information on activities in most cases. Where financing has already been committed to an activity or where the activity was costed through a transparent process we assumed that existing costs were sufficiently reliable.

more detailed feasibility studies are considered in a parallel analysis on feasibility costs conducted by the Rocky Mountain Institute. Specific limitations may include:

1. **The cost estimates provided are typically gross (rather than net) and these estimates therefore do not attempt to account for any financial or non-financial benefits or income streams that might accrue as a result of the costed actions**. This approach was selected for several reasons, which include (i) that benefits often do not accrue to the organisation who finances the intervention, (ii) benefits/income are often much more uncertain and occur later in the project than costs, (iii) to inform resource mobilisation efforts for deliver of the NDC and (iv) to allow greater comparability between estimates. Gross cost estimates can overstate the amount of financing required from external sources to achieve the relevant target, particularly in cases where the domestic income generated by a project can be significant (e.g. renewable energy generation). A more detailed cost benefit analysis will therefore need to be undertaken to determine the net impact of any action before it is implemented. The costs related to this activity are included in the parallel feasibility study analysis conducted alongside this report.

2. **Although we try to differentiate between capital costs and operational costs, this is often not possible**. As a result, summary tables aggregate capital and operational estimates to arrive at total costs. However, individual costing sections do differentiate between these cost types whenever possible.

3. **Costing generally focussed on determining indicative costs for achieving specific climate change related targets at cost-effective levels.** Programme costs might be higher than indicated if programme scope is wider than simply achieving emissions targets. For example, criteria such as political feasibility, biophysical opportunity and the co-benefits of some activities with other sustainability goals (e.g. protection of biodiversity and maintenance of ecosystems) would also need to be considered when selecting the optimal mix of activities.

4. **In some cases, estimated costs are based on high-level international average costs, rather than context-specific costs.** As a result, in most cases more granular, sector-level, research would be required to estimate the cost-effectiveness of specific investments in the context of Belize.

2.2 Land use change and forestry

Mitigation targets deemed relevant for inclusion in the NDC in the land use change and forestry (LUCF) sector are listed in Table 2. These targets are grouped within actions and the rest of this section estimates the costs of meeting these targets within each of the action groups.

Table 2 Land use change and forestry mitigation actions and targets

Action	Targets	Source documents
Sustainable forest management and land degradation neutrality	Reduce GHG emissions and increase GHG removals related to land use change totalling 2,053 KtCO2e cumulative over the period from 2021 to 2030	NDC

Action	Targets	Source documents
Mangrove protection and reforestation	Enhance the capacity of the country's mangrove and seagrass ecosystems to act as a carbon sink by 2030, through increased protection of mangroves and by removing a cumulative total of 381 KtCO2e between 2021 and 2030 through mangrove restoration.	NDC
Develop blue carbon credit market	Explore options for the sale or trading of carbon credits on the international markets	ICZMP

Source: Vivid Economics

2.2.1 Sustainable forest management and land degradation neutrality

Table 3 lists relevant targets (in blue shading) and associated activities (in white shading) for sustainable forest management and land degradation neutrality. The table also includes a high level indication of the degree to which the identified activities are sufficient to fulfil the stated targets. For activities the table also states the estimated cost or financed amount for that activity, as well as whether the activity has been financed and completed.

The gap analysis and costing for this action focuses on the NDC emissions target for reserves and sustainable forest management – (a) in Table 3 below – to avoid additional annual GHG emissions related to land use change increasing from 99 KtCO2e in 2021 to 985 KtCO2e in 2030 (up to 5,474 KtCO2e cumulative over the period from 2020 to 2030). The achievement of the other targets will also contribute to the NDC target and hence they have been included here. Specifically, in the costing analysis below we place our emphasis on target (a) in the table above, since (b) is already under way and it is assumed that (c) to (h) will be subsumed within the achievement of (a). Activities to reduce GHG emissions are selected so as to also achieve the emissions reductions goal. The only exception is for activity (e) which is costed separately, as a policy development activity in line with the costing strategy employed in the Adaptation Costs section.

Table 3 Sustainable Forest management and land degradation neutrality: Targets and activities

#	Targets and activities	Estimated Cost	Gap Analysis
1	**Sustainable forest management and land degradation neutrality:** **(a) Reduce GHG emissions and increase GHG removals related to land use change totalling 2,053 KtCO2e cumulative over the period from 2021 to 2030)** (b) Complete the REDD-plus Strategy, including options, implementation framework and assessment of social and environmental impacts, publish and maintain a National Forest Reference Level covering 2006-2020, and design systems for monitoring, information and safeguards; including stock taking for tropical forest and mangrove cover and promotion of community land stewardship practices. Participate in REDD+ for performance-based payments for emissions reductions and removals increase achieved above and beyond the commitment in this NDC. (c) Implement reforestation practices for 1,400 hectares in forest areas inside protected areas, as well as the restoration of 6,000 hectares of degraded and deforested riparian forests by 2030, with 750 hectares of this being restored in key watersheds by 2025 (d) Reduce degradation in 42,600 hectares of forest within protected areas by reducing fire incidence, improving logging practices, and controlling other human disturbance by 2030. **(e) Assess potential to reduce emissions related to fuelwood collection and use including an assessment of social and cultural impacts and collection of data on current fuelwood use in local communities throughout Belize and incorporate findings into forestry sector strategies.** (f) Incorporate and monitor agroforestry practices into at least 8,000 hectares of agricultural landscapes by 2030 by planting shade trees, in line with the draft National Agroforestry Policy, with 4,500 hectares of this being implemented by 2025 conditional on adoption, implementation and financing of the agroforestry policy (g) Promote and monitor the stewardship of 10,000 hectares of local community and indigenous people's lands as sustainably managed landscape to serve as net carbon sinks		**Partial progress**

	(h) Explore alongside Article 6 of the Paris Agreement, new financing options to support forest protection and restoration, including REDD+ performance-based payments, multilateral and bilateral funds, insurance products, debt-for-nature swaps, private investment, carbon credits and bonds, and other innovative conservation financing mechanisms		
1.1	Restoration of Riparian Forests in Watersheds (National LDN Strategy)	$7 000 000	Financed? NO Completed? NO
1.2	National REDD+ Strategy and Action Plan	$3 800 000	Financed? YES Completed? NO
1.3	Integrated management of production landscapes to deliver multiple global environmental benefits (GEF)	$14 430 464	Financed? YES Completed? NO
1.4	Integrated Ridge to Reef Management of the Mesoamerican Reef Ecoregion (MAR2R)	$12 634 664	Financed? YES Completed? NO

Source: Vivid Economics

Validation of cost estimates for existing activities

1.1 Restoration of Riparian Forests in Watersheds: The pilot project to rehabilitate degraded riparian forests within priority watershed(s) was allocated an indicative budget of USD$7 million. Given that this is a pilot project does not specify exact emissions targets or an estimate of the scale of forest restorations, it is not possible to validate this indicative budget. To get an indicative idea of the carbon emissions reduction potential of this budget: A recent WRI report indicated that reforestation of riparian forests in Guatemala to be about USD$5,803 per hectare (WRI, 2018), which would imply that a USD$7 million budget might cover 1,206 hectares. Another study suggested that riparian forests hold on average 113 tCO_2e/ha, which implies that a project of this size might be able to reduce emissions by 136.3 $KtCo_2e$. (Dybala et al, 2019). However these emission impacts are purely indicative and are not incorporated in the calculation of the overall financing gap estimation at the end of this section.

1.2 National REDD+ Strategy and Action Plan: The National Climate Change Strategy and Action Plan includes a target to develop a National REDD+ Strategy and Action Plan. This activity is currently being delivered at a cost of USD $3.8 m. Given that the costs are based on actual delivery and the activity completely covers the target, we can safely assume that the existing estimated costs are a reasonable estimate.

1.3 Integrated management of production landscapes to deliver multiple global environmental benefits: This GEF project is ongoing (from 2019 to 2024) and financing has been secured for USD$28,860,927 (from the GEF, UNDP, MNR, MOA, the University of Belize and the Santanger Sugar Group). Given this background it's likely that the estimated costs are fairly accurate and need not be validated. The project expects to result in:

- The establishment of 4,500 hectares (ha) of landscape management tools;
- 30,500 ha of landscapes under sustainable agriculture with biodiversity benefits;
- 15,000 ha of landscapes under sustainable land management in production systems;
- 750 ha of riparian forests; and,
- 300 ha of groundwater recharge areas restored in key areas of the BRW.

However, the project does not specify its contribution to the above emissions target and given that its multi-focal (focussing on both dioversity and land degradation) it should be noted that not all of the project's costs should be allocated to this action. Furthermore, the costs included here would also contribute to the goal of restoring riparian forests (with project documentation explicitly referring to clearance of riparian vegetation in the Belize River watershed), so potentially there might be some overlap with activity 1.1. Given the project's multi-focal nature, we will assume that 50% (USD$14.4 million) of the financing allocated to this activity contributes to the emissions target.

1.4 WWF-GEF Ridge to Reef (MAR2) project: This co-financed project is ongoing across 4 countries (Belize, Guatemala, Honduras, Mexico) over 5 years (2017-2022) at USD$78.5million. As the name suggests, the project aims to strengthen integrated ridge to reef management, in watersheds, freshwater and coastal resources. It is not clear from project documentation what proportion of the project's resources are focussed on specifically towards Belize (and hence applicable to this action). The project's monitoring and evaluation plan proposes 597,500 ha of the Belize River watershed will be under Integrated Water Resources Management (IWRM) activities by year 4 of the project. To estimate this proportion, we note that the Belizean government has contributed USD$8 million (32.2%) of the total USD$24.8 million contributed by national governments to this project. We therefore assume that USD$25,269,328 (i.e. 32.2% of the USD$78.5 million total budget) will be allocated towards Belize and assume that half of this amount contributes to this action (and the other half to mangrove restoration).

Gap analysis

Assuming the activities described above perform to their objectives, they have potential to deliver significant progress against the targets for the sector. Table 4 sets out at a high level the potential impacts in emissions from the activities set out above. While ranges of carbon yields from forest management vary widely, a conservative estimate ranges from 1 to 8 tons of CO2/ha/year.[2] A central value of 5 tonnes is used in the comparison shown in Table 4. This high-level analysis shows that a significant portion of the LUCF emissions target may be achieved by currently planned restoration and management projects.

Table 4 Summary of existing and planned project impacts for LUCF sector

Project	Land type, intervention	Hectares	Emissions (KtCO2e/year)	Cost (USD)	Status
Riparian forests restoration	Riparian forests, restoration	1,200 (estimate)	136	$7 million	Concept stage
GEF integrated management	Production systems, sustainable land management	35,000	175	$14 million (total project)	Funded, active
	Riparian forests, management	750	84		
MAR2	Watershed management	600,000	3,000	$10 million (share assumed for watersheds in Belize)	Funded, active

Source: Vivid Economics

Given uncertainty around the expected emissions impact of the above activities, we assume that the restoration activities included in the GEF integrated management projects will contribute to the NDC target while management activities related to both GEF integrated management and MAR2 projects will help maintain the current level of forestry-related emissions in the sector (and not contribute additional emissions reductions to the target).

[2] Richard, K.R. and C. Stokes. 2004. A Review of Forest Carbon Sequestration Cost Studies: A Dozen Years of Research. *Climatic Change* (63: 1: 1-48).

Indicative costing

To estimate the costs of meeting this gap, we consider international evidence to establish a broad range for the possible cost of meeting the second half of the NDC target to "reduce GHG emissions and increase GHG removals related to land use change totalling 2,053 KtCO2e[3] cumulative over the period from 2021 to 2030". Forest land emissions in Belize has typically been about -10 $MtCO_2e$ in recent years. In this context, this is a relatively small target, but it is unclear what the baseline counterfactual is for this estimate. Specifically, it is likely that significant activity would be required to just maintain current emissions, so achieving the increasing reductions per year is an ambitious undertaking, more so than it initially seems.

Cost estimates per tCO_2e for forestry mitigation activities have varied widely by type of activity, region, system boundaries and time horizon. The IPCC has suggested that afforestation or reforestation offer the best mitigation options (given short timescales and ease of implementation), although other activities such as reducing deforestation, forest management and forest restoration also have good mitigation potential in many cases (IPCC, 2014). Table 5, below, provides indicative estimates of what proportion of the potential mitigation impacts could be achieved within different cost bands based on global models. This reaffirms that costs per tCO_2e varies quite widely and also allows us to impute weighted average costs per tCO_2e; as we do in our scenario analysis below.

Table 5 Economic potential for forest-based mitigation options (taken from FAO, 2016)

Economic potential for forest-based mitigation options in 2030, from global models

Region/group	Afforestation				Reduced deforestation				Forest management				Total[b]
	Potential at cost up to US$100 (*Mt CO_2e/ year*)	% of total potential at different cost ranges in US$/ tonne CO_2			Potential at cost up to US$100 (*Mt CO_2e/ year*)	% of total potential at different cost ranges in US$/ tonne CO_2			Potential at cost up to US$100 (*Mt CO_2e/ year*)	% of total potential at different cost ranges in US$/ tonne CO_2			
		1–20	20–50	50–100[a]		1–20	20–50	50–100[a]		1–20	20–50	50–100[a]	
Africa	665	70	16	14	1 160	70	19	11	100	65	19	16	1 925
Central and South America	750	39	33	28	1 845	47	37	16	550	43	35	22	3 145
United States of America	445	30	30	40	10	20	30	50	1 590	26	32	42	2 045
East Asia (non-Annex I)	605	26	26	48	110	35	29	36	1 200	25	28	47	1 915
Other Asia	745	39	31	30	670	52	23	25	960	54	19	27	2 375
Middle East	60	50	26	24	30	78	11	11	45	50	25	25	135
OECD Pacific	115	24	37	39	30	48	25	27	110	20	35	45	255
Europe	115	31	24	45	10	17	27	56	170	30	19	51	295
Countries in transition	545	35	30	35	85	37	22	41	1 055	32	27	41	1 685
Total	**4 045**	**40**	**28**	**32**	**3 950**	**54**	**28**	**18**	**5 780**	**34**	**28**	**38**	**13 775**

[a] Calculated from the two columns to the left.
[b] Top-down global estimates of mitigation from wood energy and green building are not available in Nabuurs *et al.*, 2007.

Source: Nabuurs *et al.*, 2007

Source: FAO (2016), highlighted by Vivid Economics

[3] Including up to 5 KtCO2e of N2O reduction and 0.47 KtCO2e of Methane reduction from land use change

Table 6 provides cost estimates for this target under low (USD$1-20 per tCO_2e), medium (USD$20-50 per tCO_2e), high (USD$50-100 per tCO_2e) and weighted average cost scenarios. Here we make use of the mid point of each of these cost bands to produce estimates. The last line in the table provides the weighted average cost (in this case USD$33 / tCO_2e)[4] of producing the required reduction in carbon emissions, which we will use as our headline estimate for this target.

Table 6 Sustainable forestry: Indicative cost estimates under different cost scenarios

Cost assumption	Cumulative: (2,053 KtCO2e)
Average cost in low (1-20) band: **US$10 / tCO2e**	$20,530,000
Average cost in medium (20-50) band: **US$35 / tCO2e**	$71,855,000
Average cost in high (50-100) band: **US$75 / tCO2e**	$153,975,000
Weighted average cost: **US$33 / tCO2e**	**$67,749,000**

Source: Vivid Economics

There are ongoing discussions within Belize about the possibility of expanding agroforestry or silvopasture within the country. Belize's draft agroforestry policy includes preliminary targets to increase forest cover over 50,000 acres (20,200 ha) in 10 years and enable the restoration of degraded lands across another 50,000 acres in the same time period. Table 7 includes example estimated costs per tCO_2e for such interventions in Mexico and Brazil. These costs vary significantly between the three examples and are between 2 and 10 times higher than the USD$33 / tCO2e assumed above. However, such activities can also deliver many other environmental and financial benefits (that are not included in the calculation below), so a full cost benefit analysis of different forestry options would need to be undertaken before deciding what type of forestry investments to take forward.

Table 7 Estimated costs and impacts for agroforestry / silvopasture

Agroforestry / silvopasture	Silvopasture Mexico	Silvopasture Brazil	Agroforestry Brazil
tCO2e/ha over 20 years (1)	104.2	104.2	104.2
Establishment cost (2)	$2 894	$1 712	$2 086
Maintenace each year (2)	$158	$702	$1 569
Estimated 20 year cost	$6 054	$15 752	$33 466
Cost per tCO2e	$58	$151	$321

Source: 1) Vivid Economics global emissions estimate for tropical silvopasture, 2) WRI (2017)

The final action, to "assess potential to reduce emissions related to fuelwood collection", is costed as a policy development activity. This action is costed using the same cost brackets as are outlined in the Adaptation Costing section. This results in the additional cost of USD$250,000, on top of the sustainable forestry cost estimate given above.

Summary for Action 1: Reserves and Sustainable Forest Management

Target: "*Reduce GHG emissions and increase GHG removals related to land use change totalling 2,053 KtCO2e cumulative over the period from 2021 to 2032":*

Estimated total cost to meet target: $ 67.9 million

[4] This average is calculated assuming that costs are applied in line with the Central and South America Forest Management percentages highlighted in **Error! Reference source not found.**: i.e. (43% * $10 + 35% * $25 + 22% * $75) = $33

Identified activities already funded:	$ 30.9 million[5]
Identified activities not yet funded:	$ 7.0 million
Estimated gap (incl. unfunded activities):	$ 30.1 million

The estimated cost to meet the above target is highly dependent on the nature of the activities selected to meet this target. We have assumed an average cost of USD$33 / tCO_{2e}, but based on international evidence this could reasonably range between $24.7m (at USD$10 / tCO_2e) and $185.8m (at USD$75 / tCO_2e).

Relatedly, note that this costing analysis has focussed on emissions target (a) in Table 3 assuming that this will subsume all the other targets, including those addressing land degradation. However, in practice it will be important the activities to reduce GHG emissions are selected so as to also achieve the land degradation goals and to meet the Bonn Challenge commitment to reforest 100 km^2 of deforested areas. Additional costs might thus be necessary if this is not the approach taken to GHG emissions reduction.

2.2.2 Mangrove protection and reforestation

Table 8 Mangrove protection & reforestation: Indicative cost estimates under different cost scenarios

#	Targets and activities	Estimated Cost	Gap Analysis
2	**Mangrove protection and reforestation:** **(a) Enhance the capacity of the country's mangrove and seagrass ecosystems to act as a carbon sink by 2030, through increased protection of mangroves and by removing a cumulative total of 381 KtCO2e between 2021 and 2030 through mangrove restoration.** (b) Building on the 12,827 hectares of mangroves currently under protection, protect at least a further 6,000 hectares of mangroves by 2025, with an additional 6,000 hectares by 2030. **(c) Restore at least 2,000 hectares of mangroves, including within local communities, by 2025, with an additional 2,000 hectares by 2030** (d) Halt and reverse net mangrove loss by 2025 through public measures and partnerships with private landowners local communities, and other relevant stakeholders (e) Assess the value of seagrass habitat contributions to climate regulation (f) Complete an in-situ assessment of the below ground carbon stock of mangroves by 2022 (g) Explore alongside Article 6 of the Paris Agreement, new financing options to support mangrove protection and restoration (h) Throughout delivery of land use interventions related to this target, promote the stewardship of local community and indigenous people's coastal lands as sustainably managed landscapes to serve as net carbon sinks		**Partial progress**
2.1	Explore new financing options to support mangrove protection and restoration, including multilateral and bilateral funds, insurance products, debt-for-nature swaps, private investment, blue carbon credits and bonds, and other innovative conservation financing mechanisms	$5 000 000	Financed? NO Completed? NO
2.2	Integrated Ridge to Reef Management of the Mesoamerican Reef Ecoregion (MAR2R)	$12,634,664	Financed? YES Completed? NO

Source: Vivid Economics

Validation of existing cost estimates

2.1 Mangrove financing options to support protection and restoration of mangroves, including Blue Carbon Incentive: The aim of the Blue Carbon Incentive project is "the identification of degraded mangrove forests … to initiate rehabilitation activities in those areas" which will be "combined with the exploration of blue carbon accounting, management and incentive agreements in northern Belize as a stimulus for mangrove rehabilitation and protection on and along private lands" (MNR, 2020). Given that this is a pilot project does not specify exact emissions targets or an estimate of the scale of forest restorations, it is not possible to

[5] Given that the activity "Integrated management of production landscapes to deliver multiple global environmental benefits." Is multi-focal, we have assumed that only 50% of its cost is allocated to this target. As discussed, we've also allocated 32.2% of the WWF Ridge to Reef project since this project is allocated across 4 countries.

validate this indicative budget. The value of USD$5,000,000 is an estimate based on the Land Degradation Neutrality (LDN) documentation to identify various funding sources.

2.2 WWF-GEF Ridge to Reef (MAR2) project: This co-financed project is ongoing across 4 countries (Belize, Guatemala, Honduras, Mexico) over 5 years (2017-2022) at USD$78.5 million. As the name suggests, the project aims to strengthen integrated ridge to reef management, in watersheds, freshwater and coastal resources. It is not clear from project documentation what proportion of the project's resources are focussed on specifically towards Belize (and hence applicable to this action). The project's monitoring and evaluation plan proposes 597,500 ha of the Belize River watershed will be under Integrated Water Resources Management (IWRM) activities by year 4 of the project. To estimate this proportion we note that the Belizean government has contributed USD$8 million (32.2%) of the total USD$24.8 million contributed by national governments to this project. We therefore assume that USD$25,269,328 (i.e. 32.2% of the USD$78.5 million total budget) will be allocated towards Belize and assume that half of this amount contributes to this action (and the other half to riparian forest management).

Gap analysis

Estimates from a recent study (Herrera et al. 2020) suggests that mangrove protection preserves 1,279 tCO_2e per hectare and maintains annual carbon sequestration of 5.94 tCO_2e per hectare per year. Estimating how many hectares would need to be protected or restored to meet the NDC mangroves target is however quite challenging, since it requires an assumption on the degree of mangrove clearing or deforestation that would take place in the absence of such protection programmes. It is estimated that between 2000 and 2017 the total mangrove area in Belize reduced from 74,542 to 72,169 ha; an average rate of 0.19% per year. (Cherrington et al, 2020). Avoiding this rate of clearing per year would thus protect 8.34 $tCO2_e$ per hectare per year.[6] This estimate is extremely sensitive to the rate of clearing avoided: if instead the rate was 1% (the FAO's 2007 estimate of global mangrove clearing), the protection rate per year would increase to 18.73 $tCO2_e$ per hectare per year; which would more than halve the cost estimate below. This is estimate is more in line with Vivid Economics' forest mitigation calculator estimates the average global sequestration potential for mangroves to be 18 tCo2e/ha/year. However, given that deforestation rates in Belize appear to have been below international averages, we apply the lower estimate of 8.34 $tCO2_e$ per hectare per year as our headline estimate.

Indicative costing

The on-going Smart Coasts project has estimated the likely average cost of mangrove protection and restoration to be USD$63,630 per hectare. The cost per hectare is however highly dependent on whether the relevant area is already owned by the state (USD$35,595 per hectare), is donated (USD$22,239 per hectare) or whether it would need to be purchased from private owners (USD$92,662 per hectare). In the absence of information on which exact mangroves will be targeted, we therefore make use of the average cost estimate in the analysis presented here.

To meet the overarching target to "remove a cumulative total of 381 $KtCO2_e$ between 2021 and 2030 to met through mangrove protection activities", funding of USD$290,798,801 would be required. In line with above assumptions, of carbon stock preservation and sequestration at the rate of 8.34 $tCO2_e$ per hectare per year, removing 381 KtCO2e would require protection of at least 4,570 ha of mangroves. Table 9 shows a range of values for different cost assumptions. These estimates might seem relatively high compared to the sustainable forest management estimates in section 2.1.1, but this reflects the very high upfront costs that need to be undertaken to protect these mangrove areas (incl. property costs, surveys and authentication,

[6] Calculated as: (Amount of carbon stock loss avoided) + (Annual carbon sequestration maintained) = (1,279 tCO2e * 0.19%) + (5.94 tCO2e) = 8.34

consultation and legal instrument drafting). The annual carbon benefits realised will however continue indefinitely. It should also be noted that this funding could also be obtained through offset carbon markets, so the cost would not necessarily need to be fully borne by government or donors.

Table 9 Costs of meeting mangrove protection and restoration targets

Cost assumptions and outputs	Protection target	Restoration target
Total cost per hectare	$63,630	$10 000
Cost for 10,000 hectares	$636,295,400	$100 000 000
Cost for 4,000 hectares	$254,518,160	$40 000 000
Cost for 2,000 hectares	$127,259,080	$20 000 000
Total cost to meet target	**$290,798,801**	**$40 000 000**

Source: Vivid Economics

For the restoration part of the target, which is to "restore at least 2,000 hectares of mangroves, including within local communities, by 2025, with an additional 2,000 hectares by 2030", we use a USD$10,000 cost per hectare. This results in a cost of USD$40,000 to complete this target. This estimate is based on the work done by WWF. It is lower than the original WWF estimate as it separates the additional costs for education, outreach and transaction costs, though it includes carbon asset generation costs. This is the lower end cost for large pond restoration, with high end cost reaching up to USD$30,000 per hectare. These figures exclude annual land duties as well as transaction costs (stamp duty and other).

Summary for Action 3: Mangroves protection and reforestation

Target: "Enhance the capacity of the country's mangrove and seagrass ecosystems to act as a carbon sink by 2030, through increased protection of mangroves and by removing a cumulative total of 381 KtCO2e between 2021 and 2030 through mangrove restoration. Restore at least 2,000 hectares of mangroves, including within local communities, by 2025, with an additional 2,000 hectares by 2030."

Estimated total cost to meet target:	$	330.8 million
Identified activities already funded:	$	10.0 million
Identified activities not yet funded:	$	5.0 million
Estimated gap (incl. unfunded activities):	$	315.8 million

As mentioned, most of this cost reflects the total upfront cost of mangrove protection actitivities which would then yield benefits for decades into the future; which makes the cost seem extremely high. It should also be noted that this cost is highly sensitive to the assumptions of how much deforestation would take place in the absence of these mangrove protection activities.

2.2.3 Develop blue carbon market

Table 10 Blue carbon market: Indicative cost estimates under different cost scenarios

#	Targets and activities	Estimated Cost	Gap Analysis
3	**Develop blue carbon market:** Explore options for the sale or trading of carbon credits on the international markets (ICZMP)		**No activities identified**

Source: Vivid Economics

We estimate that a project of this nature might take will operate in perpetuity once established, at an annual cost of USD$214,510 per year. We furthermore assume that 2 consulting studies might be commissioned at an average cost of USD$200,000 per study. This results in a total cost of USD$2,614,510 for a 10 year period.

We have based these estimates on previous bottom-up estimates made by Vivid Economics in for the development and delivery of an emissions trading scheme in Mexico. In that case the annual cost of running such a programme was estimated to be USD$429,020 – which includes staff, service provider and operational costs. Since adjusted net national income per capita (current USD$ - based on World Bank database) in Belize (USD$3,612) is roughly half of what it is in Mexico (USD$7,447) we have adjusted costs down by 50% for the Belizean context.

Summary for Action 4: Blue Carbon Market

Target: "*Explore options for the sale or trading of carbon credits on the international markets*":

Estimated total cost to meet target:	$ 2.60 million.
Identified activities already funded:	$ 0.00 million
Estimated gap:	$ 2.60 million

2.2.4 LUCF Mitigation costs: Summary

Table 11 summarises the estimated costs and remaining financing gap for the relevant actions and targets in terms of mitigation in the Land Use Change and Forestry (LUCF) sector.

Table 11 Land Use Change and Forestry (LUCF) Mitigation: Estimated costs for actions and associated targets

#	Primary Costing Targets	Estimated total cost to meet target	Identified activities: Amount already funded	Identified activities: Unfunded amounts	Estimated gap (incl. unfunded activities)
1	**Reserves and sustainable forest management and fuel wood consumption:** Reduce GHG emissions and increase GHG removals related to land use change totalling 2,053 KtCO2e cumulative over the period from 2021 to 2030 and assess potential to reduce emissions related to fuelwood collection and use.	$67,749,000	$30,865,128	$7,000,000	$29,883,872
2	**Mangrove protection and reforestation:** Enhance the capacity of the country's mangrove and seagrass ecosystems to act as a carbon sink by 2030, through increased protection of mangroves and by removing a cumulative total of 381 KtCO2e between 2021 and 2030 through mangrove restoration and restore at least 2,000 hectares of mangroves, including within local communities, by 2025, with an additional 2,000 hectares by 2030.	$330,798,801	$10,000,000	$5,000,000	$315,798,801
3	**Blue carbon market:** Explore options for the sale or trading of carbon credits on the international markets	$2,614,510	$0	$0	$2,614,510
	Land Use Change and Forestry: Total	**$401,412,311**	**$40,865,128**	**$12,000,000**	**$348,547,183**

Source: Vivid Economics

2.3 Agriculture

Only two mitigation targets that need to be costed were identified for the agricultural sector. For simplicity these will both be discussed in one sub-section below.

2.3.1 Sustainable crop production and livestock management

Table 12 Sustainable crop production: Estimated costs for actions and associated targets

#	Targets and activities	Estimated Cost	Gap Analysis
4	**Sustainable crop production and livestock management:** (a) Avoid emissions of at least 4.5 ktCO2e related to agriculturally driven land use change by 2025 (b) 10% reduction of methane emissions related to livestock, as compared to BAU		**Minimal progress**
4.1	Biochar Production (LDN project)	$15 000 000	Financed? NO Completed? NO
4.2	Improving Livestock Sector Productivity and Climate Resilience in Belize	$875 700	Financed? YES Completed? NO
4.3	Integrated management of production landscapes to deliver multiple global environmental benefits (GEF)	$14 430 464	Financed? YES Completed? NO
4.4	Denuded agricultural land restored to arability	$1 000 000	Financed? YES Completed? NO

Source: Vivid Economics

Validation of existing cost estimates

4.1 Biochar Production (LDN project): This project considers the utilization of excess agricultural residue, for example coconut, crops, rice, sugar cane, wood shavings, etc. to supply biochar plants and using the product to improve soil quality in small, medium, and largescale farms. This project concept involves the construction and operation of regional biochar plants in Northern and Southern Belize, which can have a moderate mitigation impact by suspending carbon in charcoal format over longer periods of time than the normal decomposition process would allow for.

4.2 Improving Livestock Sector Productivity and Climate Resilience in Belize. The main objective of this project is to improve the productivity of the livestock sector in Belize through the promotion of pasture intensification, while at the same time addressing the low capacity for adaptation to climate change of especially small and medium-sized producers. As the project is already financed and underway it is clear what its total cost will be, although it's not clear how much of these costs should be allocated towards mitigation (rather than adaptation).

4.3 Integrated management of production landscapes to deliver multiple global environmental benefits: This WWF GEF project is on-going (from 2019 to 2024) and financing has been secured USD$28,860,927 (from the GEF, UNDP, MNR, MOA, the University of Belize and the Santanger Sugar Group). Given this background it's likely that the estimated costs are fairly accurate and need not be validated. The project expects to result in:

- The establishment of 4,500 hectares (ha) of landscape management tools;
- 30,500 ha of landscapes under sustainable agriculture with biodiversity benefits;
- 15,000 ha of landscapes under sustainable land management in production systems;
- 750 ha of riparian forests; and,
- 300 ha of groundwater recharge areas restored in key areas of the BRW.

However, the project does not specify its contribution to the above emissions target and given that its multi-focal (focussing on both diversity and land degradation) it should be noted that not all of the project's costs should be allocated to this action. Furthermore, the costs included here would also contribute to the goal of restoring riparian forests (with project documentation explicitly referring to clearance of riparian vegetation in the Belize River watershed), so potentially there might be some overlap with other activities. Given the project's multi-focal nature, we will assume that 50% (USD$14.4 million) of the financing allocated to this activity contributes to the emissions target.

4.4 Denuded agricultural land restored to arability: the NDC calls for 200 ha of arable sugar land to be restored. The funding for this activity comes from FAO's CSIDS-SOILCARE Phase1 initiative. It is designed for Caribbean Small Island Developing States (SIDS) as a soil management initiative to promote integrated landscape restoration and climate-resilient food systems. The overall funding of this initiative is USD$ 33.7 million, out of which USD$ 1 million is designated to Belize's restoration of denuded land.

Gap analysis

An additional activity that has not yet secured funding is the development of solar-powered irrigation systems by 2025, for which the funding required would be USD$ 10 million. The NDC calls for adoption of improved solar-powered irrigation systems, in response to which the Ministry of Agriculture, Food Security, and Enterprise estimated the cost of this intervention at USD$ 10 million. The funding sources are currently being researched.

Given the lack of specificity as to the scope or scale for these targets target, it is not clear whether meeting the target will involve anything beyond creating awareness about and advocating for crop cultivation methods and livestock management practices that could result in lower emissions. It is possible for the government to subsidise or incentivise such methods directly, but in the absence of a clear policy or programme to do so (beyond the biochar production project listed above), we will assume that such subsidies are not within scope here.

One target not considered here is the delivery of the draft agroforestry policy, which calls for 20,000 acres (8,000 ha) of agricultural landscapes to be planted with trees. Given this target may be delivered under the GEF-6 integrated management project, which calls for 35,000 ha of sustainable agriculture, this prospective target is not additionally costed.

We assume that the cost of these promotion activities (i.e. both crop production and livestock management) would each be under USD$500,000. The government could choose different forms of advocacy or information campaigns, which would affect the overall cost. We therefore cost these activities using the

same high cost-category approach we adopt for adaptation targets in section 4. Some of these costs might be able to be achieved within existing ministerial budgets, depending on the intended scale of such activities.

Summary for Action 8: Sustainable crop production and livestock management:

Targets: "(a) *Promote the reduction of agricultural GHG emissions through altering crop cultivation methods (NCCPSAP) and (b) Promote the reduction of agricultural GHG emissions through implementing effective livestock management that involves changing the feeding practices of livestock.*":

Estimated total cost to meet target:	$ 41.3 million
Identified activities already funded:	$ 16.3 million
Identified activities not yet funded:	$ 15.0 million
Estimated gap (capital and operational costs):	$ 10 million

2.4 Energy

Table 13 Energy mitigation actions and targets

Actions	Targets	Sources
Renewable energy	(a) Develop Renewable Energy to shift the energy matrix away from fossil fuels. (b) Promote and facilitate Clean Production systems in the processing of Agriculture and Forestry outputs to co-produce energy. (c) Enhancing national capacity in clean energy and clean production. **(d) 75% renewable energy share of electricity generation by 2030 by implementing hydropower, solar, wind and biomass, including scaling up solar power by 40 MW by 2025.** **(e) Expand the use of biomass, including bagasse, for electricity generation**	(a) - (c): NCCPSAP Sustainable Energy Strategy (d-e) NDC
Energy efficiency in the power sector	(a) Avoid emissions from the power sector equivalent to 19 KtCO2e per year through system and consumption efficiency measures amounting to at least 100 GWh/year by 2030 **(b) Reduce transmission and distribution losses from 12% to 10% by 2030 resulting in reduced electricity demand and better quality of supply** **(c) Improve energy efficiency and conservation by at least 10% by 2030 compared to a BAU baseline projection, including through an increase of appliance efficiency in buildings and implementation of building codes, appliance standards and labels and promotion of energy efficient technology in the tourism sector**	(a) NCCPSAP Sustainable Energy Strategy (b) NDC (c) NDC
Energy in the transport sector	**(a) Avoid 117 KtCO2e/year from the transport sector by 2030 through a 15% reduction in conventional transportation fuel use by 2030 and achieve 15% efficiency per passenger - and tonne-kilometre through appropriate policies and investments** **(b) Improve efficiency in the public transit system through the deployment of 77 hybrid and electric buses by 2030 (17 by 2025)** (c) Implement a policy framework to promote more efficient vehicles and alternative fuels/blends through incorporation of fuel economy labels; emissions testing; fuel economy standards, limitations and emissions-based taxes/feebates for imported vehicles by 2025 **(d) Facilitate adoption of electric vehicles in the passenger fleet by conducting a feasibility study for EV penetration, including assessment of potential incentives, and investing in EV charging infrastructure**	(a) 2016 NDC (b) NAMA (c) National Tourism Policy (d) NDC

Source: Vivid Economics

2.4.1 Renewable energy

Table 14 lists the five relevant targets that have been identified for the "Renewable energy" action. Amongst these targets, the focus of the costing will fall on the final two targets: (d): "75% renewable energy share of electricity generation by 2030 by implementing hydropower, solar, wind and biomass" and (e): "Expand the use of biomass, including bagasse, for electricity generation". The first three targets, which originate from the NCCPSAP Sustainable Energy Strategy are fairly broad and largely contained within (d) and (e).

Table 14 Renewable energy: Targets and activities

#	Targets and activities	Estimated Cost	Gap Analysis
5	**Renewable energy:** (a) Develop Renewable Energy to shift the energy matrix away from fossil fuels. (b) Promote and facilitate Clean Production systems in the processing of Agriculture and Forestry outputs to co-produce energy. (c) Enhancing national capacity in clean energy and clean production. **(d) 75% renewable energy share of electricity generation by 2030 by implementing hydropower, solar, wind and biomass, including scaling up solar power by 40 MW by 2025.** **(e) Expand the use of biomass, including bagasse, for electricity generation**		**Partial progress**
5.1	EcoMicro - Development Finance Corporation - Green Finance for Renewable Energy and Energy Efficiency for MSMEs	$274 500	Financed? YES Completed? NO
5.2	Belize Consolidated Project Plan	Discussed below	Financed? NO Completed? NO
5.3	Arundo Donax Biomass Pilot	$739 700	Financed? NO Completed? NO

Source: Vivid Economics

Validation of existing cost estimates

5.1 EcoMicro - Development Finance Corporation - Green Finance for Renewable Energy and Energy Efficiency for MSMEs: This is a relatively small project that is already financed and it is assumed that its likely costs are accurate. The project intends to create an enabling environment for financing green intervention, but given this structure it is not clear to what extent this project has assisted in increasing the use of renewable capacity in the country. Given this uncertainty, we assign 50% of this funding towards renewable energy targets and 50% towards energy efficiency targets, hence this project cost is USD$274,500 out of USD$549,000.

5.2 Belize Consolidated Project Plan (CPP): Given the depth of the analysis done in the CPP report, it does not produce a single cost headline cost estimate that can be easily validated. Instead, the CPP's recommendations are discussed in detail in the gap analysis below. The CPP analysis included a technical costing based on similar projects in the Caribbean, so the estimates discussed below are considered robust and evidence-based.

5.3 Arundo Donax Biomass Pilot: This is a relatively small scale pilot to explore the biomass capability of Arundo donax grass. A project of this size (USD$739,700) might be able to produce around 780 MWh per year (under the cost assumptions discussed below), which would be around 0.2% of the total renewable generation required below. Given the exploratory nature of this project it is likely that less generation results directly from this project. Therefore, while Arundo Donax might be a promising source of renewable energy, the direct impact of the funds committed to this project are not included in the analysis below.

Gap analysis

The Belize Consolidated Project Plan (CPP - Bunker et al, 2018) sets out opportunities that exist within the electricity sector and therefore acts as the framing document for costing this target. Specifically, the CPP modelled 11 different scenarios for the electricity sector to 2036 (with each scenario making different assumptions on installing new generation capacity, adding interconnections to the Mexican grid and increasing energy efficiency) and made recommendations based on which scenario scored highest based on a weighted average of several criteria. Based on the highest scoring scenario, the CPP recommends the following:

- Micro-grids: The development of remote microgrids for six specific rural communities, using both fossil fuels and renewables: Saving USD$1.5 million over 20 years. Costed in the CPP at USD$891,000.
- Grid-scale energy efficiency: implement "a 10-year energy efficiency program to save 218 million kWh, or 20 percent of total electricity needs, by 2036. At a cost of approximately USD$6 million over a 20-year period, pursuing an aggressive energy efficiency approach can save nearly USD$42 million beyond the Reference scenario".
- Grid-scale renewable energy: Continue the "the procurement process for Belize's first 15 MW of solar photovoltaics (PV) (currently underway), adding a minimum of 5 MW of additional solar PV, and adding 18 MW of wind power to the energy mix". The 18 MW of wind power was expected to be achieved through two onshore wind projects in Ambergris Caye and Maskall.

Increasing the percentage of electricity generation from renewable sources was one of the criteria used to score scenarios, but the CPP also considered factors such as sustainable economic development (including job creation), the security of supply (including reducing cost volatility) and the financial cost of each option.

As a result of weighting these other considerations, the target to achieve 75% renewables penetration is not fully achieved by the CPP – and a significant gap remains. Under all CPP scenarios, at least 35% of energy in 2036 will still be imported from Mexico. As a result, assuming that this imported energy is not generated by renewable technologies (as is currently the case – with the Mexican grid depending on fossil fuels, especially natural gas, for about 80% of its total generation), implementing the CPP's recommendations alone will not be sufficient to achieve the goal of 75% renewables. Specifically, under the CPP's recommended scenario, renewable energy penetration will only reach about 53%. The energy efficiency interventions envisioned in the CPP do help reduce the need for importing electricity, thereby increasing the renewables percentage, but a considerable gap to the 75% target still remains.

Based on a simple extrapolation of the analysis done in the CPP, we estimate that meeting the 75% renewables target would require an additional 74 MW of renewable capacity beyond what is recommended by the CPP. The CPP recommends increasing the locally generated capacity from 153 MW (across all sources, at the time of writing of the CPP report) by 82 MW, which includes new capacity in biomass, onshore wind, solar photovoltaic and hydroelectric sources. This would result in 53% renewables in 2036. To reach the 75% target assuming a similar mix of technologies and factor capacities as the CPP would require another 74 MW in renewable capacity. Under the CPP's recommended scenario a total (net present value) capital expenditure of USD $131.2 million will be required and a simple extrapolation suggests that an additional USD$162.8 million (USD$294 million in total) would be required to fully meet its 85% target by 2036. Note however that this estimated gap is highly sensitive to assumptions in the growth rate of demand (which has likely reduced due to the economic impacts of Covid-19), the mix and capacity factors of renewable technologies selected and the additional costs (including, for example, storage capacity) that might need be incurred to ensure a stable electricity supply at such a high renewable level.

Indicative costing

While the gap analysis based on CPP estimates presented above is informative, it is based on 2036 (rather than 2030) and includes a number of simplifying assumptions. We will therefore also estimate the likely cost of meeting the 75% renewable target in 2030 based on BEL's most recent growth projections and capacity factors as well as international cost estimates for different renewable technologies. Table 15 provides indicative cost levelized cost estimates for different technologies based on estimates by the USEIA, which we use in the capital cost estimates provided below. While these exact capacity factors and costs vary by project and certainly would not all translate precisely to Belize, it still provides a useful starting point for understanding likely costs.

Table 15 USEIA Estimated levelized cost of electricity (LCOE, unweighted) for new generation resources entering service in 2025 (2019 dollars per megawatt hour)

Plant type	Capacity factor	Levelized capital cost	Levelized fixed O&M	Levelized variable O&M	Levelized transmission cost	Total system LCOE
Dispatchable technologies						
Ultra-supercritical coal	85%	$47.57	$5.43	$22.27	$1.17	$76.44
Combined cycle	87%	$8.40	$1.59	$26.88	$1.20	$38.07
Combustion turbine	30%	$16.17	$2.65	$44.33	$3.47	$66.62
Advanced nuclear	90%	$56.12	$15.36	$9.06	$1.10	$81.64
Geothermal	90%	$20.38	$14.48	$1.16	$1.45	$37.47
Biomass	83%	$39.92	$17.22	$36.44	$1.25	$94.83
Non-dispatchable technologies						
Wind, onshore	40%	$29.63	$7.52	$0.00	$2.80	$39.95
Wind, offshore	44%	$90.95	$28.65	$0.00	$2.65	$122.25
Solar photovoltaic	29%	$26.14	$6.00	$0.00	$3.59	$35.73
Hydroelectric	59%	$37.28	$10.57	$3.07	$1.87	$52.79

Source: USEIA (2020)

We estimate that additional capacity of 74 MW would be required by 2030 to achieve a 75% renewables target, at a capital cost of USD$226.9 million and at total operational costs (over the useful lifetime of new generation capacity) of USD$233.1 million[7]. We assume that total grid electricity demand grows by 3.1% per annum. Increasing from 588,351 MWh in 2019 (BEL, 2020) demand would reach 823,155 MWh by 2030.[8] We further assume that all current capacity (171.2 MW across all sources) remain in use by 2030 and that the capacity factors for different technologies are in line with their 2018 levels.[9] Under these assumptions, if renewable capacity was not expanded at all, renewables be expected to generate 42.8% of the required 2030 electricity demand.[10] Table 16 lists some of the other main assumptions made.

Table 16 Main assumptions made in costing renewable energy targets

Plant type	Capacity factors (for 2018 from BEL Annual Report)	Capacity factors (for comparison, from USEIA)	% of new generation capacity (assuming tripling of biomass)	Levelized capital cost (USD$ / MWh, from USEIA)	Total system LCOE (USD$ / MWh, from USEIA)	Useful life assumptions (in years, from NREL)
Hydro	49.7%	59.0%	14.2%	$37.28	$52.79	30
Biomass	47.6%	83.0%	66.7%	$39.92	$94.83	20
Solar PV	22.5%	29.0%	10.0%	$26.14	$35.73	30
Wind (on-shore)	40.0%	40.0%	9.0%	$29.63	$39.95	20

Source: Vivid Economics, based on BEL, USEIA and NREL

In the above estimation we have assumed that the amount of energy generated from biomass is tripled by 2030. This a relatively crude way of incorporating the target 5e to "Expand the use of biomass, including bagasse, for electricity generation", which results in 66.7% of new capacity being allocated to biomass (as shown Table 16). If new generation capacity is allocated in line with CPP recommendations, capital cost estimates would fall slightly (from USD$236.8 million to USD$226.9 million), and operational costs would

[7] The operational costs listed here would include operational, transmission and maintenance costs. The number presented here represents the under-discounted version of these estimates. In practice, many of these costs would be funded contemporaneously through electricity charges to consumers.

[8] The 3.1% growth rate is based on BEL forecasts for 2019-2025. It is however possible that the decline in demand in 2020 due to the Covid-19 pandemic response will lead to a reduction in longer term growth rates; but it is not yet clear what the longer term impact will be.

[9] The severe drought in 2019 resulted in a substantial decline in the capacity factor of the Becol hydroelectric plants from 48.8% in 2018 to 13.6% in 2019. Given that that the 2018 capacity factor is much more in line with historical levels, we have used it as our baseline, but the likelihood of more frequent droughts are clearly a cause for concern in this regard.

[10] We have not included energy efficiency initiatives in this calculation, which could result in an overestimate of the total cost of meeting this goal.

increase significantly (from USD$134.6 million to USD$233.1 million) given the high LCOE that the USEIA estimated for biomass.

Summary for Action 5: Renewable Energy

Targets: "*75% renewable energy share of electricity generation by 2030" and "*Expand the use of biomass, including bagasse, for electricity generation":

Estimated total capital cost to meet target:	$ 226.9 million
Estimated operational costs to meet target:	$ 233.1 million
Identified activities already funded:	$ 0.3 million
Identified activities not yet funded:	$ 0.7 million[11]
Estimated gap:	$ 460 million

These estimate should be seen as only indicative, however, and would vary significantly based on the assumptions made including the exact technologies selected, interconnection costs and any efficiency savings that are realized in parallel. While the cost estimate is broadly in line with the gap analysis conducted for achieving the 85% by 2036 target through the CPP, it should be noted that the capital cost estimated in the CPP was a modelled amount and is not yet funded. The true gap will depend on how much the BEL and others have already committed to new renewables supply, including the success of its current RFP for solar and hydroelectricity generation. The BEL states in its 2019 annual report that it aims to invest over USD$250 million to modernizing the national electricity grid over the next five years, but this amount would cover a much wide set of activities and types of costs than our estimate above.

The costs listed above are likely to be recoverable by consumer electricity charges. These charges would be incurred by consumers regardless of whether new renewable capacity is created or whether electricity is imported.

2.4.2 Energy efficiency in the power sector

Table 17 lists the main targets related to energy efficiency (EE) in the power sector. The focus of this section is target (b), which relates to transmission and distribution (T&D) losses, and target (c) which relates to energy efficiency and conservation. Target (a) is considered covered by other targets.

Table 17 Energy efficiency in the power sector: Targets and activities

#	Definition	Estimated Cost	Gap Analysis
6	**Energy efficiency in the power sector:** (a) Avoid emissions from the power sector equivalent to 19 KtCO2e per year through system and consumption efficiency measures amounting to at least 100 GWh/year by 2030 (NDC) **(b) Reduce transmission and distribution losses from 12% to 10% by 2030 resulting in reduced electricity demand and better quality of supply (NDC)** **(c) Improve energy efficiency and conservation by at least 10% by 2030 compared to a BAU baseline projection, including through an increase of appliance efficiency in buildings and implementation of building codes, appliance standards and labels and promotion of energy efficient technology in the tourism sector (NDC)**		**Partial progress**
6.1	EcoMicro - Development Finance Corporation - Green Finance for Renewable Energy and Energy Efficiency for MSMEs	$274 500	Financed? YES Completed? NO
6.2	Belize Consolidated Project Plan	Discussed below	Financed? NO Completed? NO
6.3	Building Sector Reform Project	$70 000	Financed? TBD Completed? NO

[11] We have not included the CPP cost estimates here, since CPP cost estimates were merely recommended cost scenarios and not spending amounts committed to by the government.

6.4	Belize Energy Efficiency Labelling Scheme (Pilot)	$211 000	Financed? YES Completed? NO
6.5	Energy programme result 1: Improved infrastructure for unserved villages and households	$5 450 000	Financed? TBD Completed? NO

Source: Vivid Economics

Validation of existing cost estimates

6.1 EcoMicro – Green Finance for Renewable Energy and Energy Efficiency for MSMEs. This is a relatively small project that is already financed and hence we assume that its likely costs are accurate. The project intends to create an enabling environment for financing green intervention, but given this structure it is not clear to what extent this project has assisted in increasing the energy efficiency in the country. Given this uncertainty, we assign 50% of this funding towards renewable energy targets and 50% towards energy efficiency targets, hence this project cost is USD$274,500 out of USD$549,000.

6.2 Belize Consolidated Project Plan (CPP): The CPP was discussed in detail in section 2.4.1. The CPP does not provide a very clear cost estimate for the above targets, and funding has not been directly committed to the CPP's recommendations. However it is again a very useful starting point for determining an appropriate cost for targets (b) and (c) in the above table, and we'll use several of its assumptions in the rest of this section.

6.3 Building Sector Reform Project: The Building Sector Reform Project will gather information and data needed to strategize a legally enforceable standard building code and establish implementing partners and financing. This project clearly contributes to the achievement of target (c), but given its small size and active status, its exact contribution to this target has not been assessed.

6.4 Belize Energy Efficiency Labelling Scheme (Pilot): the European Development Fund Energy Programme has granted BZD 425,000 for piloting the energy efficiency labels, in line with the target to 'Improve capacities and enabling conditions to upscale energy efficiency measures in Belize'. The funding and pulot program are overseen by the Belize's Energy Unit and will be implemented in 2022.

6.5 Energy programme result 1: Improved infrastructure for unserved villages and households: the European Development Fund has granted EUR 4,5 million for a general infrastructural improvement program that will run between 2019-2024. The funding is not entirely related to the energy efficiency improvements, however since there is no separate mitigation target for households, it is included here.

Gap analysis

The CPP did not specifically aim to cost targets of the type considered here (i.e. transmission & distribution (T&D) losses or energy efficiency in specific sectors) and did not report an aggregate cost for energy efficiency measures. Instead it estimated a 10% overall reductions due to a range of energy efficiency measures relating to areas such as lighting, refrigeration and air conditioning at an 75% level of consumer penetration. We therefore cannot directly estimate the degree to which the CPP directly addresses the targets considered here. In addition, analysis suggests that little progress has yet been made towards achieving these targets. In 2019 T&D losses were still at 12.08%. Additionally, electricity demand grew by 3.5% per year between when the MESTPU strategic plan was written in 2012 and 2019, which does not suggest that significant efficiencies have been realised (BEL, 2020).

Indicative costing

The CPP does, however, provide valuable estimates that can be used to cost the above targets. The CPP's analysis was partly based on an earlier report on renewable and efficient energy potential in Belize (Castalia, 2014), which found that energy efficiency measures could result in a 24 percent decrease in electricity demand over 20 years. This study assessed the cost of EE measures in Belize at USD $0.105/kWh and

USD$0.121/kWh after program administration costs are accounted for. The CPP also estimated the costs and benefits of various energy generation and efficiency scenarios, finding that energy efficiency measures result in significant cost savings relative to their reference scenario. The CPP analysis eventually assumed slightly lower total costs for energy efficiency measures (USD $0.07/kWh), based on similar intervention costs for St. Lucia.

Assuming that electricity demand increases at 3.1% per annum (BEL 2019) and that EE costs are in line with the CPP (i.e. USD $0.07/kWh), a 2% reduction in T&D losses (from 12% to 10%) would cost USD$13.7 million between 2020 and 2030 (scenario 1 in Table 18 below).[12] Given that this is a considerable reduction in T&D losses that, we have used the higher unit cost estimate (USD$0.121/kWh, scenario 4) as our headline cost estimate target. Table 18 provides estimates of the possible costs of reducing T&D costs from 12% to 7%, a more ambitious and costly scenario, as well as from 12% to 10%. The NDC target opted for the latter option as recommended in the Fundación Bariloche's (2020b) draft report on energy and transport costs.

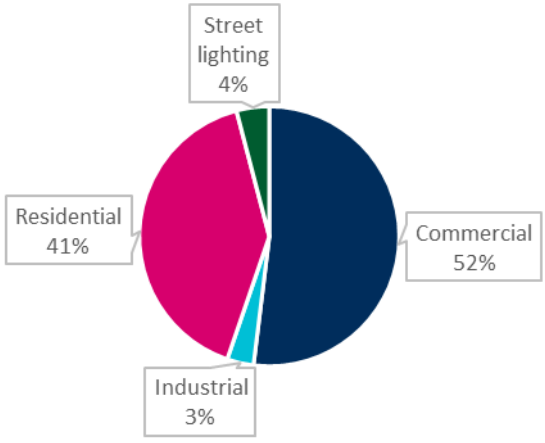
Table 18 Estimated costs of reducing Transmission and Distribution (T&D) losses

Scenario	Assumption: T&D losses (2030)	Assumption: EE Cost (USD$/ kWh)	Generation growth rate required	Total generation MWh (2030)	Total MWh avoided/saved (over 10 years)	Total cost of T&D interventions (USD$)
0: Base	12%	$0.070	3.1%	935 404	0	$0
1: 7% T&D, Low cost	7%	$0.070	2.6%	885 113	275 663	$19 296 441
2: 10% T&D, Low cost	10%	$0.070	2.9%	914 617	113 416	$7 939 095
3: 7% T&D, High cost	7%	$0.121	2.6%	885 113	275 663	**$33 355 277**
4: 10% T&D, High cost	10%	$0.121	2.9%	914 617	113 416	$13 723 293

Source: Vivid Economics

The next target aims to improve energy efficiency and conservation by at least 10% by 2030. The target also outlines sector level targets, such as an increase of appliance efficiency in buildings and implementation of building codes, as well as appliance standards and labels and promotion of energy efficient technology in the tourism sector. Figure 2, below, shows that these sector targets cover the vast majority of the electricity sector at similar efficiency rates. The 10% efficiency target will apply across sectors.

Figure 2 Grid electricity demand by sector 2019 (GWh/year)



Source: Vivid Economics, based on Fundación Bariloche (2020b)

[12] In 2019, the electricity sector generated 669.18 GWh to meet the demand of 588,35 GWh, implying T&D losses of 12.08%

Under the CPP's EE cost assumption of USD $0.121/kWh, the total cost of reducing electricity demand by 10% would be USD$79.3 million over the course of ten years (see Table below). This assumes that demand would grow by 3.1% per annum in the absence of EE interventions. Reducing electricity demand across the economy by 30% by 2033 implies an annual growth rate in demand of only 0.3% per year, with the amount of emissions saved gradually increasing each year. This calculation thus assumes that EE measures are gradually introduced throughout the 13 year period. Under the assumption that the country can implement the most cost effective efficiency measures first, therefore using the lower cost assumption from the CPP (USD $0.07/kWh), the total cost would be USD$45.9 million. However, in order to remain consistent with the previous calculations and further in line with the Castalia (2014) study, we follow the cost assumption of USD$0.121 kWh, leading to the headline cost of USD$79.3 million.

Table 19 Estimated costs of Improve energy efficiency and conservation by at least 10%

Scenario	Assumption: Annual EE savings by 2030	Assumption: EE Cost (USD$/ kWh)	Demand average growth rate	Electricity Demand 2030 (MWh)	Total MWh avoided/saved (over 10 years)	Total cost of EE demand interventions (USD$)
0: Base	0%	$0.070	3.1%	823,155	-	$0
1: 10% EE @ Low cost	10%	$0.070	1.7%	740,840	655,743	$45,902,039
2: 10% EE @ High cost	10%	$0.121	1.7%	740,840	655,743	$79,344,954

Source: Vivid Economics

An important simplification we've made is to focus on an reduction of 10% in aggregate energy intensity rather than a 10% reduction in per capita energy intensity. The original MESTPU strategic plan stated the target as "The goal is to achieve a minimum reduction in per capita energy intensity of at least 10 per cent by 2030, using energy utilization and GDP generated in 2011 as the baseline." However, we have not tried to separate demand growth into population growth and per capita growth. Instead, given the lack of data on the determinants of the forecasted electricity demand growth, we have decided to rather take the more conservative aggregate approach.

Summary for Action 6: Energy Efficiency

Targets: "*Reduction in transmission and distribution losses from 12% to 10% by 2030 resulting in electricity savings"* and *" Improve energy efficiency and conservation by at least 10% by 2030*":

Estimated total cost to meet target:	$ 93.1 million.
Identified activities already funded:	$ 0.3 million
Identified activities not yet funded:	$ 5.7 million
Estimated gap (capital and operational costs):	$ 87.1 million

While these EE costs might seem high, they would likely on net save, rather than cost, money for the country as a whole. For example, reducing T&D losses will require less energy to be generated to meet the same levels of demand and will therefore reduce the costs of generating or importing energy.

Additionally, if these energy efficiency (EE) measures are implemented in full, significantly less electricity generation will be required than would otherwise be the case, which will make the renewable energy targets in the previous section less costly to achieve. However, given that EE interventions at this scale are not yet underway, we costed the renewable energy targets independently; without assuming that EE targets would be met.

2.4.3 Energy in the transport sector

This section will focus on estimating the likely cost of meeting the 117 KtCO2e/year reduction in emissions from the transport sector. The actions are mostly based on those outlined in NAMA and the NDC.

Table 20 Energy efficiency in the transport sector: Targets and activities

#	Targets and activities	Estimated Cost	Gap Analysis
7	**Energy in the transport sector:** **(a) Avoid 117 KtCO2e/year from the transport sector by 2030 through a 15% reduction in conventional transportation fuel use by 2030 and achieve 15% efficiency per passenger - and tonne-kilometre through appropriate policies and investments** **(b) Improve efficiency in the public transit system through the deployment of 77 hybrid and electric buses by 2030 (17 by 2025)** (c) Implement a policy framework to promote more efficient vehicles and alternative fuels/blends through incorporation of fuel economy labels; emissions testing; fuel economy standards, limitations and emissions-based taxes/feebates for imported vehicles by 2025 **(d) Facilitate adoption of electric vehicles in the passenger fleet by conducting a feasibility study for EV penetration, including assessment of potential incentives, and investing in EV charging infrastructure**		**Minimal progress**
7.1	NAMA Component 1: Acquisition of efficient buses (diesel/hybrid/electric) plus relevant infrastructure (charging)	$56 000 000	Financed? Unknown Completed? NO
7.2	NAMA Component 2: Transport Mode Integration	Included above	Financed? Unknown Completed? NO
7.3	NAMA Component 3: Regulatory framework and capacity building	Included above	Financed? Unknown Completed? NO

Source: Vivid Economics

Validation of existing cost estimates

Activities 7.1 to 7.3 listed above focus heavily on the public transport sector (as this was the focus of the Transport NAMA process) and it will be assumed that completing these activities will be sufficient to achieve the deployment of hybrid and electric buses by 2030, as well as the 15% fuel and efficiency per passenger targets. These three activities were designed and costed in depth as part of the NAMA process and hence we assume that the above cost estimates are appropriate for achieving the relevant targets within the public transport sector.

Gap analysis

The activities listed above however appear to have relatively little influence on the private vehicle market. As a result, filling the overall gap would likely require reducing the fuel consumption and emissions of private owned vehicles. The rest of this section therefore focusses on what might be done to achieve a 15% reduction in fuel consumption in the private vehicle market.[13]

In estimating what activities might be necessary to meet the above targets in the private sector, we will focus on the percentage change in efficiency, rather than on a specific numeric emissions target. This reflects the fact that the first target (a 15% reduction in conventional transportation fuel) could be interpreted as either an absolute reduction over the current baseline or as a reduction over the Business-as-Usual (BAU) estimates for 2030. Considering baseline Transport emissions of 0.67 $MtCO_2e$ in 2015 baseline year, the target could imply on a reduction of at least 0.13 $MtCO_2e$ on an annual basis, but we will instead focus on a relative change in consumption and emissions.

[13] Our analysis of policy documents has not identified any climate related interventions in terms of trucks; and therefore this section focusses only on private road vehicle; although most of the interventions discussed here could also be adapted to the truck market.

While a 15% reduction in fuel use is quite ambitious, there appears to be opportunity to achieve this level of reduction in Belize given the current high level of emissions and inefficiency in the transport sector. Average vehicle CO_2 emissions (g/km) were 325.7 in 2016 in Belize, which is higher than regional comparators and much higher than other parts of the world such as the European Union (where average emissions are around 100 g/km). These high emissions reflect the large number of pick-up trucks and vans in the national fleet rather than smaller cars; which is likely driven by both the Belizean import tax regime (trucks and vans are taxed at 27%, while cars and minivans at 66.5% FB (2020b)) and the quality of roads in some areas of the country. Large changes in efficiency would thus be possible through a shift in the profile of the fleet (i.e. more sedan cars relative to vans and pick-ups). The fuels used in Belize are also significantly less efficient than those used in, for example, Mexico.

The 2019 Mitigation Assessment and Strategy report (Gauss International Consulting, 2019) identified the following light duty vehicle interventions for consideration in the Belizean context, ranked from least to most costly:

a) Energy efficiency standards and labels for cars
b) Fiscal measures on cars such as taxes on imports of vehicles, registration of cars or in circulation (based on vehicle CO2 emission intensities)
c) Tax on fuels to incentivise import of more refined fuels
d) Awareness campaign for more energy efficient driving
e) Retro-fitting vehicles with LPG fuel systems
f) Subsidies for purchase of fuel efficient vehicles

As part of the 2020 NDC preparations, Fundación Bariloche estimated the likely carbon emissions reductions that could likely be achieved through each of these of these interventions; as displayed in the final column of Table 21.[14] The estimates suggest that the target of 15% reduction in emissions can be achieved and even surpassed by 2030 by implementing these interventions.

Table 21 Estimated 2030 emissions impact of different light duty vehicle interventions in Belize

Measure	Net incidence	Emission reduction (for those affected)	Aggregate emissions reduction
a. Energy efficiency standards and labels for cars	2.5%	50%	1.25%
b. Fiscal measures on cars			
Differential registration tax	7.67%	50%	3.84%
Differential circulation tax	7.67%	50%	3.84%
Duties on imported vehicles	7.67%	50%	3.84%
c. Tax on fuels for incentivising more import of more refined fuels	35%	20%	7.00%
d. Awareness campaign for more energy efficient driving	30%	5%	1.50%
e. Retro-fitting vehicles with LPG fuel systems	15.0%	10.5%	1.58%
Total			**22.83%**

Source: Fundación Bariloche (2020b)

Given that interventions (a) to (d) from Table will in aggregate achieve an over 20% reduction in fuel efficiency and emissions, the rest of this section will aim to provide the total cost of implementing this group of interventions. From a cost perspective there could be economies of scale for designing, implementing and enforcing related policies through a single initiative.

[14] Subsidies for the purchase of fuel efficient vehicles was the only one of the measures listed above not considered. This intervention was also not mentioned in target 7b in Table ; and hence we have not included it in the costing below.

Indicative costing

Implementing the interventions identified above – i.e. energy efficiency labels and standards, fiscal measures on cars, fuel taxes and efficiency driving awareness campaigns – would require significant upfront research and scoping costs in the early years followed by on-going annual administration costs. Intuitively these costs depend significantly on how and by whom these interventions are regulated and administered. For example, some of these costs could likely be absorbed within existing ministerial budgets. However, for this exercise we assume that costs are largely supplementary to existing budgets; although clearly existing government and political staff's time would also be taken up during the scoping phase of these programmes.

We estimate that the costs of jointly researching, scoping and capacity building for these interventions over 10 years would be approximately USD$5 million[15]. This assumes an average annual cost of USD$500,000 per year, however it is more likely that the initial costs will be lower, conducting preparatory research, planning and capacity building, therefore ramping up the costs post 2025. This amount being allocated roughly in the following way:

(1) A one year research project and consultation into the likely economic and environmental impacts of these interventions.
(2) Over the following three to four years various projects to design, write and approve the relevant regulation, taxation rules, efficiency standards and labels.
(3) Over the remaining five to six years, implement, monitor and administrate the various interventions. An annual cost of USD$500,000 could likely fund 30 – 40 staff to perform these tasks based on programme cost estimates done by Vivid Economics in Mexico (adjusted to the Belizean context).

The estimates presented above are gross costs, which do not include the revenues that would be generated from any taxes or duties.

Note that the costs of retrofitting with LPG fuel systems or providing subsidies for the purchase of efficient vehicles have not been included in the above cost estimates. These costs have been excluded since (a) the target could be achieved without these initiatives and (b) the impact of these initiatives would likely depend largely on the scale of government subsidies or incentives, making it difficult to tie cost estimates to impacts.

A final cost that should be considered relates to the final target, of facilitating the adoption of EV vehicles and investing in EV charging infrastructure. The research and policy drafting costs are captured under the aforementioned discussed cost of USD$5 million for research, scope and capacity building. After stakeholder consultations with the ministry, the EV charging infrastructure costs were estimated to reach an additional USD$10 million. This is a high level estimate and is subject to change, however is is included as a best available cost estimate to reach this target right now.

Summary for Action 6: Energy Efficiency

Targets: *"Avoid 117 KtCO2e/year from the transport sector by 2030 through a 15% reduction in conventional transportation fuel use by 2030 and achieve 15% efficiency per passenger - and tonne-kilometre through appropriate policies and investments" and "Improve efficiency in the public transit system through the deployment of 77 hybrid and electric buses by 2030 (17 by 2025)" and "Facilitate adoption of electric vehicles in the passenger fleet by conducting a feasibility study for EV penetration, including assessment of potential incentives, and investing in EV charging infrastructure"*:

[15] Note that after the consultation with stakeholders, the Implementation Plan costs research and capacity building activities until 2025 at USD$ 1.5 million. As described above, it is reasonable to assume that these activities will be scaled up towards 2030, resulting in the total cost of USD$ 5 million.

Estimated total cost to meet target (private vehicles):	$ 15.0 million
Estimated NAMA cost to meet target (public sector):	$ 56.0 million
Total Estimated costs / gap:	$ 71.0 million

2.4.4 Energy Mitigation costs: Summary

Table 22 summarises the estimated costs and financing gap for the relevant actions in terms of mitigation in the Energy sector. The table also provides the estimated costs of existing or planned activities based on the relevant source documentation for these activities, although as was discussed in detail earlier, it is not always easy to summarise all relevant costs in a single number; as is particularly the case for the Belize Consolidated Project Plan.

Table 22 Energy Mitigation: Estimated costs for actions and associated targets

#	Primary Costing Targets	Estimated total cost to meet target	Identified activities: Amount already funded	Identified activities: Unfunded amounts	Estimated gap (incl. unfunded activities)
5	**Renewable energy**: (i) 75% renewable energy share of electricity generation by 2030 by implementing hydropower, solar, wind and biomass. (ii) Particular focus on expanding the use of biomass, including bagasse, for electricity generation	$460,050,610	$274,500	$739,700	$459,036,410
6	**Energy efficiency in the power sector**: (i) Reduction in transmission and distribution losses from 12% to 10% by 2030 resulting reduced electricity demand and better quality of supply (NDC) (ii) Improve energy efficiency and conservation by at least 10% by 2030 compared to a BAU baseline projection	$93,068,247.00	$274,500	$5,731,000	$87,062,747
7	**Energy in the transport sector**: (i) Avoid 117 KtCO2e/year from the transport sector by 2030 (ii) Improve efficiency in the public transit system through the deployment of 77 hybrid and electric buses by 2030 (iii) Facilitate adoption of electric vehicles in the passenger fleet by conducting a feasibility study for EV penetration, including assessment of potential incentives, and investing in EV charging infrastructure	$71,000,000	$0	$0	$71,000,000
	Energy: Total	**$624,118,857**	**$549,000**	**$6,470,700**	**$617,099,157**

Source: Vivid Economics

2.5 Waste Management

Although, several climate related targets were identified (listed in Table 23), the costing presented here will focus on target (a) "Improve waste management processes, to avoid emissions of up to 18 KtCO2e per year by 2030, in line with the national waste management strategy". Targets (b), (c) and (e) are already completed and not included in the analysis. We interpret target (d) as specifying some of the activities that need to be undertaken to implement target (a); and therefore it will effectively be covered by target (a). Finally target (f) is not explicitly included given a lack of support for it at this point, although initiatives related to landfill gas utilisation will still be considered in the implementation of target (a).

Table 23 Waste mitigation actions and targets

Action	Targets and activities	Source
Waste management	**(a) Improve waste management processes to avoid emissions of up to 18 KtCO2e per year by 2030, in line with the national waste management strategy** (b) Complete the Solid Waste Management Plan (c) Continue implementation of the Solid Waste Management Project (SWMP) (d) Close dump sites including those at Belize City, Burrell Boom, San Pedro, Caye Caulker, and San Ignacio/Santa Elena (Dumpsites in these municipalities have been closed with waste now transported exclusively to the Transfer Station Facilities. All remaining municipal open dumpsites will be also closed and replaced by the Transfer Station Facility (for the recovery of recyclables) and the Regional Sanitary Landfill (for waste disposal)). Develop similar interventions to improve waste disposal within the southern and northern thirds of the country (e) National Integrated Solid Waste Management Programme, initiatives including: Institutional strengthening; Waste segregation, storage, collection and transport; waste minimization, re-use and recovery; Cost recovery; and Education awareness and stakeholder communications. (f) Nationally Appropriate Mitigation Action (NAMA) plan, including measuring, reporting and verification (MRV) and financing options for CDM capping and closing open dumps, capturing and utilizing landfill gas, and ensuring proper waste handling and organics management	(a) 2016 NDC (b) – (d) GSDS (e) – (f) NCCPSAP

Source: Vivid Economics

2.5.1 Waste management

Table 24 Waste Management strategy and policy: Estimated costs for actions and associated targets

#	Targets and activities	Estimated Cost	Gap Analysis
8	**Waste Management:** (a) Improve waste management processes to avoid emissions of up to 18 KtCO2e per year by 2030, in line with the national waste management strategy		**Partial progress**
8.1	Solid Waste Management Project II	$10 200 000	Financed? YES Completed? No

Source: Vivid Economics

Validation of existing activity cost estimates

8.1 Solid Waste Management Project II: The objective of the project is to support Belize in its efforts to reduce environmental pollution through the improvement of solid waste management practices in emerging tourism destinations in northern and southern Belize. Specifically, the project will finance investments to improve solid waste transport, recovery, and final disposal in towns and villages in the Northern (Orange Walk and Corozal) and Southern (Stann Creek and Toledo) Corridors and in Belmopan, and to strengthen SWaMA as the lead agency in the waste management sector. Of the $10.2 million allocated to the project $8.3 million will be allocated towards capital investments (closure of dumpsites, construction of transfer

stations and construction of new cell at Mile 24), while $0.87 million is allocated to institutional strengthening and capacity building. The remaining $0.83 million is allocated to project management.

The project is already financed and underway, and hence we assume that these cost estimates are reliable and can be fully allocated to the broader implementation of the national waste management strategy. In terms of outcomes, the project aims to increase the number of households who dispose solid waste in a sanitary landfill from 30,653 to 75,277; and the tonnes of solid waste disposed in sanitary landfills from 28,861 to 87,246.

Indicative costing

As cost estimates for this target, we rely on those generated in the National Solid Waste Management Strategy and implementation plan (NSWMSIP); as this plan is the clearest articulation of what it would mean to achieve this target. The waste management target considered here does not include specific quantitative targets, which makes it difficult to directly estimate the cost or make international cost comparisons.

The NSWMSIP estimated total capital investment costs to be $67.4 million over 22 years (between 2015 and 2034), as summarised in Table 25 below. These capital investment costs mostly relate to the expansion and upgrading of waste collection services (such as transfer sites) and the development of additional sanitary landfill facilities.

Table 25 Projected capital cost (USD$ millions) of implementing the NSWMSIP between 2015 and 2034

Year	2015-24	2025-34	Total	% of total
Capital Investment Costs (CAPEX)				
Collection	$12.9	$20.1	$33.0	49%
Civic Amenity sites	$0.7	$0.0	$0.7	1%
Transfer	$7.1	$0.4	$7.5	11%
Treatment	$3.4	$0.0	$3.4	5%
Final Disposal (landfill)	$13.5	$9.3	$22.8	34%
Total CAPEX	**$37.6**	**$29.8**	**$67.4**	

Source: GoB (2015) NSWMSIP

The NSWMSIP also presents estimates of the annual cash operating costs associated with the provision and operation of the upgraded and additional waste handling systems and facilities required, which totals $260 million over 20 years (see Table 26). These costs increase over time, as the volume of MSW collected is projected to increase from about 49,000 tonnes in 2015 to 218,000 tonnes in 2034. As with capital costs, by far the largest part of the estimated total annual operating costs over the Strategy period relates to the provision of waste collection services (~78%), followed by waste transfer and final disposal (~20%). These results are not surprising and are in line with the experience of other countries that operate modern, high-quality MSW collection and disposal systems.

Table 26 Projected annual operational costs (USD$ millions) of implementing the NSWMSIP between 2015 and 2034

Year	2015	2024	2025-34 (average)	Cumulative total	% of total
Operating Costs (OPEX)					
Collection	$0.00	$10.9	$14.6	$197.9	76%
Civic Amenity sites	$0.00	$0.1	$0.1	$1.3	0%
Public awareness for recycling	$0.00	$0.0	$0.0	$0.5	0%
Transfer	$0.55	$1.4	$1.8	$27.2	10%
Treatment (net of revenues)	$0.00	$0.3	$0.0	$1.9	1%
Final Disposal (landfill)	$0.37	$1.2	$2.2	$31.2	12%

Total OPEX	**$0.91**	**$13.91**	**$18.75**	**$260.00**	

Source: GoB (2015) NSWMSIP

In practice, both capital and operational costs should be recovered from households through user fees; although affordability analysis in the MSWMSIP suggests that for lower income households such fees might need to be subsidised by the government.

Summary for Action 10: Waste management

Target: "*Improved waste management processes, to avoid emissions of up to 18 KtCO2e per year by 2030, in line with the national waste management strategy*":

Estimated total capital costs to meet target:	$	67.4 million
Estimated total operational costs to meet target:	$	260 million
Already financed costs (SWMP II)	$	10.2 million
Estimated gap (capital costs and operational costs):	$	317 million

It should be noted that for these costs we relied fully on the estimates from the NSWMSIP, given that costs of the large number of activities included in the strategy cannot easily be validated without a much more extensive exercise. Although the NSWMSIP estimates related to the period from 2015 to 2034, we have kept retained all these costs for the next 20 years, as it is not clear which of the activities intended for the NSWMSIP have already been completed.

2.6 Mitigation costs summary

Table 27 summarises the estimated costs for the relevant mitigation actions across all 4 sectors.

Table 27 Mitigation: Estimated costs for actions and associated targets across all sectors

Sector	#	Action	Estimated total cost to meet target	Identified activities: Amount already funded	Identified activities: Unfunded amounts	Estimated gap (incl. unfunded activities)
LUCF	1	Reserves and sustainable forest management	$67,999,000	$30,865,128	$7,000,000	$30,133,872
	2	Mangrove protection and reforestation	$330,798,801	$10,000,000	$5,000,000	$315,798,801
	3	Blue carbon market	$2,614,510	$0	$0	$2,614,510
	LUCF Subtotal		**$401,412,311**	**$40,865,128**	**$12,000,000**	**$348,547,183**
Agriculture	4	Sustainable crop production & lifestock mngmt	**$41,306,164**	**$16,306,164**	**$15,000,000**	**$10,000,000**
Energy	5	Renewable energy	$460,050,610	$274,500	$739,700	$459,036,410
	6	Energy efficiency in the power sector	$93,068,247.00	$274,500	$5,731,000	$87,062,747
	7	Energy in the transport sector	$71,000,000	$0	$56,038,000	$14,962,000
	Energy Subtotal		**$624,118,857**	**$549,000**	**$62,508,700**	**$561,061,157**
Waste	8	Waste Management	**$327,400,000**	**$10,200,000**	**$0**	**$317,200,000**
Total Mitigation Costs			**$1,394,237,332**	**$67,920,292**	**$89,508,700**	**$1,236,808,340**

Source: Vivid Economics

3 Adaptation costs

This section provides high level estimates of financing required to achieve priority adaptation target actions.

Where possible, target actions are costed based on identified activities in Belize. Table 28 shows the cost bands applied to target actions for which there are no activities identified or there is minimal target coverage. These bands were developed based on identified activities in Belize in the relevant target category. For infrastructure, sustainable practices and economic instruments target actions, this approach is not used since the cost of these actions varies more widely. Where appropriate, for these targets a relevant cost band may be applied from another category. For example, a sustainable practices target action may require similar activities to a research target action, and the research cost band will be applied.

Table 28 Adaptation category costing bands

Category	Description	Costing band
Infrastructure	Target actions that require investing in or improving the resilience of infrastructure for climate adaptation	Not applicable since action costs vary significantly among identified projects.
Monitoring	Target actions that require building monitoring, reporting and verification (MRV) capacity, conducting MRV assessments, or collecting data on adaptive capacity/resilience or emissions	$500,000 - $2 million
Research	Target actions that require collecting data, conducting scoping or feasibility exercises, or undertaking research to inform strategies and policies	<$500,000
Engagement	Target actions that require undertaking community engagement, education, or stakeholder consultation	<$500,000
Sustainable practices	Target actions that require supporting practices that improve adaptive capacity, resilience, reduce degradation or enable emissions reductions	Not applicable since action costs vary significantly among identified projects.
Policy development	Target actions that require enabling or supporting the development of strategies, policy or legislation	<$500,000
Institutional capacity	Target actions that require supporting institutional capacity building explicitly or implicitly	<$500,000
Economic instruments	Target actions that require creating incentives for sustainable practices or conservation through economic instruments	Not applicable since action costs vary significantly among identified projects.
Conservation	Target actions that require conserving resources or vulnerable ecosystems	$2-10 million

Source: Vivid Economics

The costing for each sector is presented in the fame format, summarised in a table. The Target column indicates which target (T) or action (A) the costing relates to. In the Implementation Plan, these correspond to outputs and outcomes. The Policy/Framework column outlines which national policy the specific action relates to or was inspired by when considering it for the NDC. The Type and Cost Band columns relate to the categories from Table 28 and the Coverage determines what proportion of the band amount is assigned to each action. Finally, Methodology/ Notes explains the reasoning behind the assigned cost.

Costs aggregated by sector indicate that almost $146 million is required to meet adaptation targets. The aggregated costs are estimated using the average value of the applied costing band. For example, a target that is in the $2-10 million costing band is estimated as $6 million. For targets in the <$500,000 band, the full $500,000 is used. For targets where there is "partial coverage", we indicate the relevant costing band for the full target, and provide an indicative estimate of coverage of cost required (either 25%, 50% or 75%) for the purposes of estimating cost requirements by sector. Table 29 shows the funding committed and requested from activities identified through stakeholder engagement (see Summary Action 1-Pagers) in addition to the funding requirements estimated in this report.

Table 29 Summary of funding committed, requested and required to meet adaptation target actions (USD)

Sector	Total cost	Funding Committed / Requested	Funding Requirements
Coastal and marine resources	$35,684,740	$23,934,740	$11,750,000
Agriculture	$113,474,000	$41,474,000	$72,000,000
Water resources	$25,117,112	$14,112,000	$11,005,112
Tourism	$35,554,715	$18,604,715	$16,950,000
Fisheries and aquaculture	$12,978,000	$12,228,000	$750,000
Human health	$12,571,575	$4,300,000	$8,271,575
Land use, human settlements, and infrastructure	$82,747,969	$57,697,969	$25,050,000
Total	$318,128,111	$172,351,424	$145,776,687

Note: Funding committed is the cost of activities identified which have been funded. Funding requested is the cost of activities identified which have not been funded or where it is unknown if the activity has been funded. Funding requirements is the sum of costing estimates for target actions laid out in this report for targets recommended

Source: Vivid Economics

3.1 Agriculture

Table 30 Agriculture sector target action costs

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
T1) Improved resilience in agricultural sector				$42.5 million	Many of the adaptation action costs listed below are cited directly from the Ministry of Agriculture, Food Security, and Enterprise. Since they are linked to potential funding sources or cited as expert estimates, they are kept in their original amounts rahter than using the cost brackets as in other sections.
A1) Public awareness campaign for climate smart agriculture, particularlty targeting practices in sugar cane production	NCCPSAP includes climate smart agriculture targets	Engagement	Full coverage	<$500,000	The cost band for engagement target actions is applied
A2) Strengthen capacity for relevant government and academic institutions in CSA, as well as participating financing institutions	NCCPSAP includes climate smart agriculture targets	Institutional capacity	Full coverage	$ 6 million	Cost cited by the Ministry of Agriculture, Food Security, and Enterprise, proposing it under the Climate Resilient Sustainable Agriculture Project
A3) Climate resilient practices upscaled among sugar farmers in Orange Walk and Corozal districts	NCCPSAP includes climate smart agriculture targets	Institutional capacity	Full coverage	$ 18 million	Cost cited as part of the Building the Adaptive Capacity of Sugarcane Farmers in Northern Belize project; funding provided from GCF
A4) Implementation of sustainable water and land	NCCPSAP includes climate smart agriculture targets	Institutional capacity	Full coverage	$ 1 million	Cost cited as part of the Building the Adaptive Capacity of Sugarcane Farmers in Northern Belize project; funding provided from GCF

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
management techniques to build farmer resilience					
A5) Capacity building and improving learning mechanism for long term adaptation to climate threats and impacts	NCCPSAP includes climate smart agriculture targets	Institutional capacity	Full coverage	$ 1 million	Cost cited as part of the Building the Adaptive Capacity of Sugarcane Farmers in Northern Belize project; funding provided from GCF
A6) Climate Resilient Value Chains Developed by 2023	NCCPSAP includes climate smart agriculture targets	Institutional capacity	Full coverage	$7.9 million	Cost cited as part of the Resilient Rural Belize (Be-Resilient) project, funded by GCF and implemented by Ministry of Agriculture, Food Security, and Enterprise
A7) Climate Resilient Rural Infrastructural Assets Developed, such as rural road improvements, small-scale irrigation and drainage, Climate Information System	NCCPSAP includes climate smart agriculture targets	Infrastructure	Full coverage	$ 8 million	Cost cited as part of the Resilient Rural Belize (Be-Resilient) project, funded by GCF and implemented by Ministry of Agriculture, Food Security, and Enterprise
T2) Reduce post-harvest losses	National Adaptation Strategy to Address Climate Change in the Agricultural Sector			$29 million	The total cost is based on the estimates of the specfifc actions as outlined in the Implementation Plan
A1) Deliver the short term actions in National Adaptation Strategy to Address Climate Change in the Aricultural Sector	National Adaptation Strategy to Address Climate Change in the Agricultural Sector	Engagement	Partial coverage	As discussed	These activities were cited and costed at $13 million in the Third National Communication. The cost is not split out between the various individual actions, hence the cost bracket is left empty, but it is considered in the total cost.

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
A2) Establish a financing facility for climate smart agriculture	National Adaptation Strategy to Address Climate Change in the Agricultural Sector	Institutional capacity	Full coverage	$16 million	Cost cited by the Ministry of Agriculture, Food Security, and Enterprise as part of the Climate Resilient Sustainable Agriculture Project
A3) Improve access to drought tolerant crops and livestock breeds	National Adaptation Strategy to Address Climate Change in the Agricultural Sector	Engagement	Partial coverage		These activities were cited and costed at $13 million in the Third National Communication. The cost is not split out between the various individual actions, hence the cost bracket is left empty, but it is considered in the total cost.
T3) Improved resilience in agricultural sector				$500,000	Additional to the part of $13 million cited above, however not counted here to avoid double counting
A1) Expanded awareness and coverage of Belize Agriculture Information System	NDC	Institutional capacity	Partial coverage		These activities were cited and costed at $13 million in the Third National Communication. The cost is not split out between the various individual actions, hence the cost bracket is left empty, but it is considered in the total cost.
A2) Pilot the agricultural insurance scheme	NCCPSAP	Institutional capacity	Full coverage	<$500,000	The full target falls under the institutional capacity cost band, <$500,000.

Source: Vivid Economics

3.2 Coastal and marine resources

Table 31 Coastal and marine resources sector target action costs

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
T1) Increased resilience to climate impacts for coastal communities and habitats by improved management of the coastline to reverse net coastal habitat and land loss by 2025	NCCPSAP / NDC / ICZMP			$ 9.5 million	The total cost is based on the estimates of the specfifc actions as outlined in the Implementation Plan
A1a) Impacts of climate change and development on coastal ecosystems identified and communicated: CZMAI intends to establish a digital library to improve stakeholder access to coastal zone data and information in building national and regional awarness on health and resiliency of coastal zones	ICZMP	Conservation	Minimal coverage	$2-10 million	The cost band for conservation target actions is applied
A1b) Impacts of climate change and development on coastal ecosystems identified and communicated: complete an impact study of ocean acidification on coastal areas and marine resources and establish an ocean acidification monitoring program	NCCPSAP	Monitoring	No activities identified	$500,000 - $2 million	The cost band for monitoring target actions is applied
A2a) Regulatory framework updated to improve protection of coastal areas: assessment and revision of current legislation and coastal development policies to identify areas for improvement	ICZMP	Policy development	Minimal coverage	<$500,000	The cost band for policy development target actions is applied
A2b) Regulatory framework updated to improve protection of coastal areas: national policy for resilient coastal habitation developed by 2023	ICZMP / NCCPSAP	Policy development	No activities identified	<$500,000	The cost band for policy development target actions is applied

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
A2c) Regulatory framework updated to improve protection of coastal areas: update Integrated Coastal Zone Management Plan by 2023	ICZMP	Policy development	Minimal coverage	<$500,000	The cost band for policy development target actions is applied
A2d) Regulatory framework updated to improve protection of coastal areas: develop national marine dredging policy with guidelines for minimising coastal impacts by 2023	National Environmental Policy and Strategy	Policy development	No activities identified	<$500,000	The cost band for policy development target actions is applied
A2e) Regulatory framework updated to improve protection of coastal areas: implement informed zoning scheme for coastal area by 2025	ICZMP / NCCPSAP	Monitoring	No activities identified	$500,000 - $2 million	The cost band for monitoring target actions is applied
T2) Advanced knowledge of the habitat coverage and carbon stocks of seagrass meadows by 2025				$ 0.75 million	The total cost is based on the estimates of the specfifc actions as outlined in the Implementation Plan
A3a) Improved seagrass habitat protection and management: conduct an assessment of seagrass habitat contributions to carbon sequestration	ICZMP, Fisheries Resources Act 2020; National Fisheries Policy, Strategy and action plan 2020	Research	No activities identified	<$500,000	The cost band for research target actions is applied
A3b) Improved seagrass habitat protection and management: develop and adopt a national seagrass management policy	ICZMP, Fisheries Resources Act 2020; National Fisheries Policy, Strategy and action plan 2020	Policy development	No activities identified	<$500,000	The cost band for policy development target actions is applied
A4) Updated forest inventory to include seagrass and below ground mangrove contributions	ICZMP	Research	No activities identified	<$500,000	The cost band for research target actions is applied

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
T3) Strengthened resilience of coastal communities by developing an early warning system for storm surges by 2025				$1.5 million	The total cost is based on the estimates of the specfifc actions as outlined in the Implementation Plan
A5) Coastal adaptation strategy developed by 2025. High-level adapation strategies for the coastal zone should be identified through readiness project that can be priortized for implementation in the near term	ICZMP / NCCPSAP	Policy development	No activities identified	<$500,000	The cost band for policy development target actions is applied
A6) Early warning system for storm surges implemented throughout coastal areas	NCCPSAP	Monitoring	No activities identified	$500,000 - $2 million	The cost band for monitoring target actions is applied

Source: Vivid Economics

3.3 Fisheries and aquaculture

Table 32 Fisheries and aquaculture sector target action costs

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
T1) Build capacity in fisheries and aquaculture sector through research, diversification and retraining to support livelihoods while protecting coastal ecosystems	NCCPSAP/NDC	-	-	$ 0.75 million	The total cost is based on the estimates of the specfifc actions as outlined in the Implementation Plan
A1) Expanded management systems to promote sustainable marine activities in place, with a particular focus on	NCCPSAP/NDC	Policy development	No activities identified	<$500,000	The cost band for policy development target actions is applied

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
conservation and management plans for marine protected areas, as well as for marine replenishment zones					
A2a) Capacity developed to support transition to more sustainable fishing and marine harvesting/extraction activity: establishing research partnerships	NCCPSAP/NDC	Research	No activities identified	<$500,000	The cost band for research target actions is applied
A2b) Capacity developed to support transition to more sustainable fishing and marine harvesting/extraction activity: strengthening fisher organisations by conducting alternative likelihods research, providing training and other capacity building efforts	NCCPSAP/NDC	Institutional capacity	No activities identified	<$500,000	The cost band for institutional capacity target actions is applied

Source: Vivid Economics

3.4 Human health

Table 33 Human health sector target action costs

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
T1) Strengthened adaptive capacity in the health sector by assessing vulnerability and investing in responses to climate-related threats	NCCSAP/NDC	-	-	$ 8.27 million	The total cost is based on the estimates of the specfifc actions as outlined in the Implementation Plan
A1) Improved understanding of climate change impacts and threats on Belize's health system and objectives, particularly conducting an assessment of Belize's health sector climate change vulnerability and response capacities	NCCSAP/NDC	Research	No activities identified	<$500,000	The cost band for research target actions is applied

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
completed by 2022 for arboviruses (expand on initial assessment)					
A2a) Improved management of tropical diseases related to climate change: establishing research partnerships for the control and management of climate-related disease by 2025	NCCSAP	Institutional capacity	No activities identified	<$500,000	The cost band for institutional capacity target actions is applied
A2b) Improved management of tropical diseases related to climate change: assessment of staff capacity and establishment of Rapid Multidisciplinary response Team	NCCSAP	Institutional capacity	No activities identified	<$500,000	The cost band for institutional capacity target actions is applied
A2c) Improved management of tropical diseases related to climate change: assessment of capacity of health staff in Integrated Vector Management (Environmental Health and Vector Control) and training individuals in disease control and vector management	NCCSAP	Institutional capacity	No activities identified	<$500,000	The cost band for institutional capacity target actions is applied
A3) Improve the capture, management and monitoring of diseases and vectors affected by climate change and related forecasting and early-warning systems.	NCCSAP/NDC	Monitoring	No activities identified	$500,000 - $2 million	The cost band for monitoring target actions is applied
A4) Promote greater investment in health Infrastructure to ensure increased access of population to improved health care, which could include retrofitting health facilities and equipment (e.g. Mobile Health Clinics,	NCCSAP/NDC	Infrastructure	No activities identified	$2-10 million	After a consultation with the Ministry of Health & Wellness, it was communicated that there are plans to have USD$4,271,575 invested in climate-proofed health infrastructure by 2025. The $2-10 million cost band is applied.

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
Amphibious Ambulance Services) and new building codes for health facilities					
A5) Develop education awareness programme to educate population on adaptation measures as it relates to family health and hygiene.	NCCSAP/NDC	Engagement	No activities identified	<$500,000	The cost band for engagement target actions is applied

Source: Vivid Economics

3.5 Land use, human settlements and infrastructure

Table 34 Land use, human setlements and infrastructure sector target action costs

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
Communities protected from damage caused by flooding and sea level rise through implementation of the Land Use Policy and supporting green and grey infrastructure	NCCPSAP / NDC / National Climate Resilience Investment Plan / Land Use Policy and Policy Framework	-	-	$25.05 million	The total cost of all the below activities to achieving this target
A1) Undertake a comprehensive assessment of human settlements, refuggee flows and related infrastructure at risk from the effects of climate change, using inter alia, risk mapping and incorporate findings into the National Land Use Management Plan	NCCSAP	Research	No activities identified	<$500,000	The cost band for research target actions is applied
A2) Land Use Policy and Framework finalised by 2022	NCCSAP / Land Use Policy and Policy Framework	Policy development	No activities identified	<$500,000	The cost band for policy development target actions is applied

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
A3) Land Use Policy and Framework provides mechanism for the incorporation of local and indigenous community land stewardship practices by 2022	REDD+ strategy	Policy development	No activities identified	<$500,000	The cost band for policy development target actions is applied
A4) Conduct LiDAR Survey for remainder of country (76% of country remains), focusing on catchment areas, to prepare investment plans (NCRIP update). Track the number of climate change adaptation plans for vulnerable areas delivered by 2025	NCCSAP	Policy development	No activities identified	<$500,000	The cost band for policy development target actions is applied
A5a) Improved adaptive capacity for communities and economic sectors thanks to more resilient infrastructure. Climate-proofed infrastructure investment plan (NCRIP) for vulnerable areas reflecting adaptation and resilience-building strategies updated. This should include actions around improving survey control network (horizontal and vertical) for more accurate infrastructural designs. Targeted areas include Belize City, Dangriga, Belize River Valley Area, Monkey River, Rural Cayo, Albion Island (OW)	National Climate Resilience Investment Plan	Infrastructure	No activities identified	$10-50 million	There is a relevant GEF project in El Salvador that aims 'create new protected wetlands' and with an estimated cost of $11 million. Scaling based on the relative length of coastline, this indicates that the cost for similar project in Belize would be $13.8 million.[16] The $10-50 million costing band is applied.

[16] https://www.thegef.org/project/conservation-sustainable-use-biodiversity-and-maintenance-ecosystem-services-internationally

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
A5b) Improved adaptive capacity for communities and economic sectors thanks to more resilient infrastructure. This action focuses on transport and water investments delivered under Climate Resilient Infrastructure project, focusing on projects such as replacement of small bridges and culberts and updgrade of farm roads in vulnerable rural and urban areas	National Climate Resilience Investment Plan	Infrastructure	No activities identified	$10-50 million	This is an estimate based on the expert valuation from the Ministry of Infrastructure Development and Housing's Senior Executive Engineer

Source: Vivid Economics

3.6 Tourism

Table 35 Tourism sector target action costs

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
T1) Increased adaptive capacity of tourism sector through the development of climate resilient planning frameworks and infrastructure	NDC / National Sustainable Tourism Master Plan / National Tourism Policy	-	-	$16.95 million	The total cost of all the below activities to achieving this target
A1) Improve the understanding of climate vulnerability of tourism sites by conducting a vulnerability assessment of coastal tourism, as well as the carrying capacity assessment of vulnerable sites	NDC / National Sustainable Tourism Master Plan	Policy development	No activities identified	<$500,000	The cost band for policy development target actions is applied

Target	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
A2) Mainstream climate change in the National Tourism Master Plan, to support adaptation measures, especially on the coastline, but also to further promote environmental and responsible tourism best practices.	NDC	Policy development	Partial coverage	<$500,000	The full target falls under the policy development cost band, <$500,000. There is an activity which mainstreams climate change into tourism plans, but additional mainstreaming may be required. The costing estimate assumes 75% of the target is covered.
A3) Identify a number of site-specific infrastructure investment plans for tourism areas reflecting adaptation strategies	NDC / National Tourism Policy	Policy development	No activities identified	<$500,000	The cost band for policy development target actions is applied
A4a) Install appropriate infrastructure and processes in local destinations for adaptation to climate change, recycling and waste treatment and other aspects of environmental management.	National Tourism Policy	Infrastructure	No activities identified	$10-50 million	There is no estimate of costs in NDC or NCCPSAP for this target action, however, NCRIP estimates $16.2 million is required for formainstreaming climate in tourism and transportation. Therefore, the $10-50 million cost band is applied.
A4b) Improve infrastructure to facilitate increased access to sites and resources. This includes the paving of roads, renovation of docking facilities for water taxis and installation of professional signage at critical junctions.	NCCSPAP	Infrastructure	No activities identified	$10-50 million	There is no estimate of costs in NDC or NCCPSAP for this target action, however, NCRIP estimates $16.2 million is required for for mainstreaming climate in tourism and transportation. Therefore, the $10-50 million cost band is applied.

Source: Vivid Economics

3.7 Water resources

Table 36 Water resources sector target action costs

Target / Actions	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
T1) Enhance the protection of water catchment (including groundwater resources) areas and make improvements to the management and maintenance of existing water supply systems.	NCCPSAP/NDC	-	-	$11 million	The total cost of all the below activities to achieving this target
A1) Hydrological resource monitoring system in place. This includes designing the development of groundwater hydrological monitoring network by 2022 and activating the monitoring stations by 2025.	NCCPSAP/NDC	Monitoring	No activities identified	$500,000 - $2 million	Monitoring target action cost band
A2) Hydrological resource monitoring system in place. Development of national hydrological drought action plan and the National Flood Early Warning System (FEWS) by 2025	NCCPSAP/NDC	Monitoring	No activities identified	$500,000 - $2 million	Monitoring target action cost band
A3) IWRM agency launched by 2022	NCCPSAP/NDC	Monitoring	No activities identified	USD $1,000,000	As set out in the sector adaptation strategy
A4) National Integrated Water Resources Management progam initiated by 2023	NCCPSAP/NDC	Policy development	No activities identified	<$500,000	

Target / Actions	Policy/Framework	Type	Coverage	Cost band	Methodology/Notes
A5) National Water Resources Adapation Plan developed by 2023, in addition to specific strategies for the determination of the transboundary Yucatan Candelaria aquifer.	NCCPSAP/NDC	Monitoring	Minimal coverage	USD $1,005,112	Valuation based on the readiness proposal submitted to support the capacitation and empowerment of the National Hydrological Service to manage Belize's water resources
A6) Investments made into climate-proof infrastructure to support water access and resilience by 2025	NCCPSAP/NDC	Infrastructure	Minimal coverage	$5 million	National Climate Reslience Investment Plan sets out required infrastructure investments, which are reflected in the land use, human settlements and infrastructure sections. The value of USD $5 mln here reflects the costs of preparation and initial cleaning, as advised by the ministry.
A7) Water quality monitoring system and management program in place, including both the build up of the system and establishment of a task force to supervise it	NCCPSAP/NDC	Monitoring	Minimal coverage	$500,000 - $2 million	Even though this combines the capacity building and monitoring, the monitoring target action cost band is applied

Source: Vivid Economics

4 Staff time, expertise and tools required to deliver the NDC

Delivering the NDC requires mobilisation and coordination of a variety of resources, as is apparent from the wide scope of the targets. Spanning across nine sectors, the targets require different resources, ranging from staff time to organise public awareness campaigns, to technical expertise to design and incorporate new agroforestry practices. Besides the monetary cost, which was discussed at length in this report, another type of resource, the human resource, is particularly key to identify. In order to carry out the outlined actions, capacity and expertise need to be built up, to ensure there are enough qualified actors that will drive the target delivery forward.

Identifying the human resource required to delvier the NDC is a complex task, that requires widespread stakeholder engagement to understand the current skill availability and identify potential capacity gaps. The findings of this section are based on a Climate Change Stakeholder Survey that was carried out in 2018. The aim of the survey was to analse the adaptation and mitigation activities that are on the stakeholders' agendas, as well as to identify outstanding organizational needs or gaps. The selected stakeholders were both from government and non-governmental organizations, within technical, financial, scientific, and social and environmental sectors. A total of 48 respondents across 44 organizations participated in the survey.

The stakeholder engagement targeted organizations from sectors that either have the most impact on climate change or are the most vulnerable to its effects. These are identified as key players both in terms of climate change action and impact, with the most pressing need to ensure they have the correct awareness, skillset and capacity. The survey explored this in four sections:

- "General": opening questions to identify the respondents' sector and its relation to climate change, particularly aiming to understand the organizational perception of climate change
- "Risks and Risk Management": identifying how climate change may impact the organization and whether there are any preventative strategies in place or under development
- "Climate Change Adaptation and Mitigation": introducing the concepts of adaptation and mitigation to ensure a unified understanding of their definition for all resondents; examining whether the organization is already involved in any activities that fall within these two areas, especially related to greenhouse gas emissions reductions or monitoring and evaluation frameworks
- "Stakeholder Engagemetn and Capacity Building": identifying high priority areas for action and capacity building opportunities; findings of this section feed in to the NCCO's identification of capacity gaps and aid in designing the correct approach and funding schemes to address those.

4.1 Sectoral summary of Adaptation and Mitigation strategies identified by the stakeholders

4.1.1 LUCF

The stakeholders representing the LUCF sector were the Association of Protected Areas Management Organizations, Belize Audubon Society, Wildlife Conservation Society and the Forest Department which run the Key Biodiversity Areas (KBA) Project (2014-2019) at the time, promoting rehabilitation of degraded areas.

The stakeholders showed good awareness of the importance of sustainable forestry and the need for community management in order to preserve and resotre forested land. The mitigation actions that were already taking place focused on conservation of forested land and reforestation, particularly developing the Protected Area management in preventing illegal forest clearance. Capacity building seems to be required from the policy perspective, ensuring the law and enforcement of forest protection is widely known and respected. The mitigation community based actions promoted more efficient wood burning stoves in communities around the Cockscomb Basin Wildlife Sanctuary, building the local understanding of the impacts of mishandling of local resources.

Adaptation actions that were identified were promoting environmentally friendly operations on site at parks e.g. use of solar energy, as well as designing community outreach programs to support forest based livelihoods. Here again, the capacity gap seems to lie in the knowledge and awareness of the interdepenecen between local communities and forest management. Empowering and educating the local communities could turn them into forest stewards, building resilience both for the ecosystem and their economic wellbeing.

4.1.2 Energy

Some of the key stakeholders representing the energy sector were the Belize Electric Company Ltd, Belize Electricity Ltd and the Energy Unit.

The mitigation actions focus on energy efficiency improvements and scoping the potential for renewable energy transition. With regards to the former, the actions range from exchanging all light bulbs to LED (the PALCEE Project in Dangriga, Hope Creek, and Sawaree) to large-scale projects, aiming to implement more Energy Conservation Measures in public buildings, (like the Energy for Sustainable Development Project). Adaptation actions of energy efficiency aim to pilot study for installation of transmission poles that can withstand extreme weather events, e.g. fibre glass poles. As to renewable action, the Energy Unit set a target to reduce the country's dependence on fossil fuels consumption by 50% by 2020 and conduct feasibility studies to incorporate wind and solar energy, in order to facilitate the transition to renewable sources. There is also scoping for the feasibility of EV infrastructure and deployment of EV vehicles.

These actions highlight the human resource needs, which are varied for this sector. There is need for knowledge building and theoretical expertise on the renewable energy systems in order to conduct the feasibility studies and design policies to enable the transition. There is also a need for on-the-ground workers, technicians and engineers to deliver the infrastructural construction on the ground, as well as operate them afterwards. The NCCO should conduct further research to understand the level of knowledge sharing required to attain those resource capacities.

4.1.3 Agriculture

Agriculutre is a very climate sensitive sector and therefore 12% of all stakeholders came from this sector. The organizations included the Caribbean Agricultural Research and Development Institute, Belize Agricultural Health Authority, InterAmerican Institute for Cooperation on Agriculture, Ministry of Agriculture, and Ya'axche, among others.

In the survey, farmers were identified as the second most vulnerable group of persons, after low income families. For farmers, changing climatic conditions that lead to decreasing crop yields emerge as a real threat, where famines, loss of landmass, soil leaching, among other effects would directly affect their livelihoods. They may also lack in transferrable skills to shift away from agriculture into jobs in other sectors. At the same time, they may require upskilling to shift from traditional farming practices towards sustainable and regenerative agriculture.

Therefore, the capacity building actions in this sector include efforts such as promotion and training for farmers in adopting climate smart agriculture for cereals, root crops; installing weather monitoring stations for farmers to use to help guide planning periods; and implementing implementing specific projects to increase climate resilience of farmers, for example the InterAmerican Institute's project on integrated soil fertility management in the banana industry.

4.1.4 Waste

The main stakeholder in the waste sector is the Belize Solid Waste Management Authority. At the time of the study, their mitigation action was closure of open dump sites at municipal level and adaptation focused on designing a better system for disposal of municipal waste for five transfer station. As discussed in section 2.5, the NDC builds on these actions, aiming to complete the closure of dump sites, extend the disposal of municipal waste program to rural areas and create a monitoring and evaluation system. The resource gap in this sector seems to be small, given the Solid Waste Management Projects are already in place and being carried out. It seems that the main constraining factor is mobilisation of monetary resources and staffing, in order to carry out the actions.

4.1.5 Transport

The key stakeholders that were surveyed for the transport sector are the Belize Customs & Excise Department, who helped in the development of the Nationally Appropriate Mitigation Action (NAMA) Concept for the Transport Sector and the Department of Transport. The latter focused their mitigation actions around designing private transport emission control schemes, promoting electric vehicle deployment and upgrading the local public transport system. All of these actions are reflected in the NDC. There are two main resource gaps identified in this sector. The first relates to the knowledge capacity of understanding and scope for emissions control, eg. How laws around traffic control could translate into reduced emissions. The second gap relates to the country's capacity to introduce hybrid or EV vehicles on its roads, requiring both skills in the manufacture and repair of such vehicles, as well as construction capacity to build the relevant infrastructure, such as the EV charging stations.

4.1.6 Coastal and marine resources

The key stakeholders that took part in the survey on behalf of the coastal sector included the Coastal Zone Management Authority & Institute, Turneffe Atoll Sustainability Association and the World Wildlife Fund, whose capacity building actions focused on building understanding of ecosystem-based adaptation approaches for coastal protection, such as promoting mangroves and shrimp farming to protect the coast and studying the resilience of coral reefs as well as marine species in face of changing temerpatures and acidity of the seas and oceans. The human resource element here is key in knowing how to manage the local esosystesm to leverage the greatest benefits, which also translate into large cost savings in the future from reducing the reliance on climate resilient infrastructure.

4.1.7 Fisheries and aquaculture

The main consultation was carried out with the Fisheries Department, whose mitigation and adaptation actions were consolidated in the Marine Conservation and Climate Adaptation Project (MCCAP). They span actions such as development of new fisheries, value-added products, increase monitoring, increase replenishment zones, reduce unsustainable fishing as well as promoting alternative livelihoods. The human resource capacity gap therefore lies in both skills around sustainable fishing practices and allowing natural replenishment of the fishing stocks, as well as potentially providing workshops around transferrable skills.

4.1.8 Water

The stakeholder consultation took place mainly with the National Hydrological Service, Belize Water Services Limited. Not many capacity building activities were identified in the water sector at the time of the survey, which highlihgts an important capacity gap to be addressed. Water quality and availability is particularly sensitive to climate change. Less rainfall and increased temperature will lead to increased evapotranspiration and loss of available freshwater, due to limited inflow to water reservoirs. Decrease in precipitation will reduce groundwater and aquifer recharge, increase salt water intrusion and contamination of freshwater resources. These impacts to water supply can cause water insecurity, in turn affecting all other sectors. These pose threats to local ecosystems and local communities. The NDC outlines new actions around building equipment to monitor water quality and quantitity, which would require specialist skills for operation and management. Further human resources would be required to design and navigate the hydrological drought action plan and the National Flood Early Warning System (FEWS).

4.1.9 Health

The health sector is seen as quite vulnerable to climate change, as the health of many will be affected by increased temperature, precipitation variability and spread of pests and diseases. These can all lead to increased morbidity, heat stress, and an increase in outpatient services due to lack of resources. In the survey consultation with the Ministry of Health, there were plans to build SMART health facilties and develop multi-hazard plans, to create contingency schemes in face of these added stresses. The NDC also focuses on establishing research partnerships to understand the impact of climate-related diseases and train sufficient staff in dealing with those. In terms of SMART infrastructure, human resource needs to be devoted to retrofitting of health facilities to offset impacts of potential climate disasters and create contingency plans for the eventuality of their occurrence.

4.1.10 Tourism

Tourism is certainly a sector that is percevived as vulnerable to climate change, especially since it is mostly eco-based and depends on the natural structures and monuments that Belize has to offer, such as coastal beaches, caves and forests, however it also stands to gain from the planned sustainable development. It is expected that critical benefits include medium to long term changes in the sector, related to construction, infrastructure and adaptation and mitigation measures. This would ensure the sector's long term sustainability and viability.

The stakeholders involved in the surveys were the Ministry of Tourism, Belize Tourism Board, Belize National Tour Guide Association, Belize Hotel Association, Belize Tourism Industry & Association. The capacity building actions included the delivery of quarterly training sessions to the accommodation sector in contingency planning and resiliency adaptation efforts, replicated from the PADF/Belize project that was executed in Southern Coastal Belize. Additional resources are necessary to conduct the vulnerability assessment for key tourist destinations, from experts who recognise both the climate change related stresses as well as business implications for the sector. The understanding and knwoelde gained from these assessments would be translated into the Development of Crisis Management Plans for Tourism Destinations, which could also include mentions of how to diverstfy tourism within emerging destinations to minimize vulnerability of sector to major disaster.

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Appendix A Additional international cost estimates

For the forestry related intervention considered in section 3.1, we did not separate different types of costs or considered the different durations of projects; although Box 1 does provide some indicative cost estimates specifically related to transaction costs.

Box 1 Transaction costs for CDM forestry projects

The table below provides transaction cost estimates per tCO_2e for (CDM eligible) forestry projects – specifically afforestation and reforestation projects. Avoided deforestation, forestry management and agroforestry are not likely to be allowed as CDM projects. Nonetheless these provide indicative estimates.

This suggests transaction costs related to 2,477 $KTCO_2e$ would be £1 733 900 ($0.7 * 2 477 000 tCO_2e) .

More generally the report finds that "CDM transaction costs per tCO2–eq reduction are small compared to the credit price. For example, assuming a credit price of 20 $/tCO2 eq, the transaction costs are in the range of .05-3.5% of the credit price." Although it should be noted that forestry transaction costs are likely slightly above the upper end of this estimate.

For CDM forestry projects (category VI), no information is available on the various cost components of the transaction costs (identification, feasibility, insurance, negotiation, regulatory, monitoring & verification). More general transaction cost information (Sathaye and Antinori, 2004) is therefore used for the present study. Table 2.5 summarizes the transaction costs for forestry mitigation projects.

Table 2.5 *Transaction costs of forestry projects*

Amount of CO_2 eq reduced annually [tCO_2 eq]	Transaction costs per tCO_2 eq reduced [$]
less than 370,000	1.4
370,000 - 3,400,000	0.7
more than 3,400,000	0.1

Source: Cost figures based on data gathered from 11 forestry projects in India, Bolivia, Brazil, US and Chile and presented by Jayant A. Sathaye, Camille Antinoiri (LBNL, Berkeley and Ken Andrasko (US Environmental protection) at workshop on Modeling to Support Policy, Shepherdstown 2004.

Source: Wetzelaer et al (2007)

Note: The above table only looks at CDM eligible projects. From the report: "*In total, 180 options for GHG emissions reduction reported in the abatement costing studies are considered not eligible for CDM, of which 54 are avoided deforestation options, 54 as agroforestry and 72 other options. All these non-eligible options have been left out for the construction of the MAC curves.*"