CLIMATE CHANGE ASSESSMENT

I. BASIC PROJECT INFORMATION

Project Title:	NEP (54107-001): Electricity Grid Modernization Project (including Additional Financing components)		
Project Cost:			
Modality and Source	Amount ($ million)		
ADB	EGMP	AF	Total
Ordinary capital resources (Concessional Loan)	156	60	216
Co-financing			
None	0	0	0
Counterpart			
Government of Nepal	39	15	54
Total	**195**	**75**	**270**
Location:	Nepal[1]		
Sector/Subsectors:	Energy/Electricity Transmission and Distribution		
Theme:	Inclusive economic growth; Environmentally sustainable growth		

Brief Description:

The proposed project will finance high-priority electricity grid modernization investments both in transmission and distribution system in Nepal under the following EGMP outputs: Output 1: electricity transmission capacity in project areas strengthened and modernized; Output 2: electricity distribution system in project areas modernized; and Output 3: capacity of NEA and electricity users in project areas strengthened. Additional Financing: This additional financing will yield expansion of outputs 1 and 2 (transmission and distribution network expansion and strengthening) of the ongoing EGMP project. Under output 1, additional 16 km 132 kV transmission line from Kohalpur to Nepalgunj and from Chovar to Lagankhel, plus an additional 501 megavolt-ampere (MVA) of substation capacity in Dumkibas, Lagankhel, Mulpani and Nepalgunj. Under output 2, an ERP system and a revenue management system will be implemented to modernize and better integrate NEA's financial and customer information systems. These outputs will result in the following outcome: accessibility, reliability and efficiency of electricity supply in Nepal improved.

Nepal's power sector is challenged by (i) limited generation capacity during the dry season forcing a reliance on imported electricity, with possible adverse impacts on Nepal's energy security; (ii) bottlenecks in downstream transmission and sub-transmission networks limiting NEA ability to deliver electricity to its customers; (iii) high technical and commercial losses due to deteriorated and under capacity network assets, weak billing practices and collection inefficiencies; and (iv) lack of institutional capacity to prepare and invest in resilience. The energy sector is highly sensitive to fluctuations in rainfall and increases in temperature. The location, design, and specifications of the infrastructure need to take these sensitivities into account to ensure climate resiliency of the subprojects/investments.

Climate change in general may have impacts on power system design, markets and operation. These can range from short-term damage due to increasing frequency and severity of storms to slow onset events such as rising temperatures. In addition, severe weather can cause large-scale power outages making the energy supply chain, particularly power generation, transmission and distribution highly at risk due to climate change (worst case scenario). From the CRVA study it was found that such impacts are not likely to happen in the short term during the project's life cycle (30 years). The anticipated impacts can be mitigated by adaptation measures proposed in section IV.

ADB = Asian Development Bank, CRVA = Climate Risk Vulnerability Assessment, EGMP = Electricity Grid Modernization Project, ERP = enterprise resource planning, NEA = Nepal Electricity Authority.

[1] (i) automation of about 34 existing grid substations throughout the Nepal; (ii) construction of 88 km of 132 kilovolt (kV) and 25 kilometer (km) of 220 kV new transmission lines; (iii) upgradation of existing 120 km 132 kV transmission lines with more efficient high-temperature-low-sag conductors, (iv) construction of distribution command and control center in Kathmandu; (v) installation of smart meters for 350,000 customers in Kathmandu Valley; and (vi) construction of distribution system consisting of 30 km long 33 kV distribution lines in Morang district and 5 automated substations in various parts the country commissioned benefitting 134,000 households (Madichaur, Keraun, Borang, Pantang and Surkhet).

II. SUMMARY OF CLIMATE CHANGE FINANCE

Project Financing		Climate Finance[a]			
Source	Amount ($ million)	EGMP Adaptation ($ million)	EGMP Mitigation ($ million)	AF Adaptation ($ million)	AF Mitigation ($ million)
ADB	**216.0**				
Sovereign Project (Concessional Loan): Ordinary capital resources	216.0	1.8	88.9	0.53	26.92

ADB = Asian Development Bank, AF = additional financing, EGMP = Electricity Grid Modernization Project.

[a] Climate Finance (mitigation and adaptation) for the project was calculated based on ADB's Guidance Note on Counting Climate Finance (January 2017) on Energy Sector, available project documents, Bill of Quantities and previous experiences with ADB on similar projects in Energy sector.

III. SUMMARY OF CLIMATE RISK SCREENING AND ASSESSMENT

A. Sensitivity of Project Component(s) to Climate/Weather Conditions and Sea Level	
Components **I. EGMP** **Output 1: Electricity transmission capacity in project areas strengthened and modernized.** The project will finance (i) automation of about 34 existing grid substations throughout the country; (ii) construction of 88 km of 132 kV and 25 km of 220 kV new transmission lines (Dandakhet-Rahughat 132 kV transmission line: 25 km, Madichaur-Gorahi 132 kV transmission line: 40 km, Borang-Lapang 132 kV transmission line: 23 km, Lapang-Ratomate 220 kV transmission line: 25 km); (iii) installation of automated 220 kV grid substations of cumulative size 400 MVA and 132 kV of 455.5 MVA installed (Rahughat: 220 kV 200 MVA, Lapang: 220 kV 200 MVA; 12.5 MVA 132 kV at Lapang; 30 MVA 132 kV substation each at Dandakhet, Rahughat, Madichaur, and Borang; 63 MVA 132 kV at Pangtang; and 130 MVA 132 kV substations each at Keraun and Surkhet); and (iv) upgradation of existing 120 km 132 kV from Pathlaiya to Dhalkebar in Province 2, 30 km 132 kV Duhabi to Kusaha in Province 1, and 35 km 66 kV inside Kathmandu Valley in Bagmati Province transmission lines with more efficient high-temperature-low-sag conductors. **Output 2: Electricity distribution system in project areas modernized.** This will include construction of distribution command and control centre in Kathmandu with at least 30% female staff; installation of additional smart meters for remaining 350,000 customers in Kathmandu Valley and construction of distribution system consisting of 30 km long 33 kV distribution liens in Morang district and 5 automated substations of 48 MVA 33/11 kV in various parts the country commissioned benefitting 134,000 households (8 MVA 33/11 substation each at Madichaur, Keraun, Borang, Pantang and 16 MVA 33/11 kV substation at Surkhet). About 2,000 electricity consumers including at least 30% women in project areas will benefit from knowledge on safe and efficient use of electricity.	Sensitivities Increased warming could exacerbate thermal overloading of power lines, reducing the amount of electricity that can be transported. Changes in precipitation patterns and surface water discharges, as well as an increasing frequency and/or intensity of droughts, may adversely impact hydropower generation and consequently affect the amount of electricity transmitted into the system. Non-climatic factors for reduced water availability may include increased competition over water use for hydropower production, irrigation, and other purposes. Substations and distribution systems may be damaged by extremely intense rainfall leading to floods or landslides. Almost all of Nepal's land area is subject to landslides due to mountainous topography, and all river basins are subject to flash-flooding. However, most of the project components will be in areas of relatively low topographic relief in the Kathmandu valley and Province 2. Routing surveys and final design incorporate best engineering practice which is to avoid landslide and flood-prone areas in principle. If routing cannot avoid such areas, the foundations of transmission towers and distribution poles will be reinforced to withstand maximum credible landslide and flood scenarios.

II. Additional Financing	
This additional financing will yield expansion of output 1 and 2 (transmission and distribution network expansion and strengthening) of the ongoing EGMP project. Under **output 1**, additional 16 km 132 kV transmission line from Kohalpur to Nepalgunj and from Chovar to Lagankhel, plus an additional 501 MVA of substation capacity in Dumkibas, Lagankhel, Mulpani and Nepalgunj. Under **output 2**, ERP system and a revenue management system will be implemented to modernize and better integrate NEA's financial and customer information systems.	

Sensitivity

- **medium sensitivity** to increased temperature
- **medium sensitivity** to increased rainfall intensity
- **medium sensitivity** to increased extreme weather

Note: The sensitivity to climate parameters is considered for short term i.e., for the project's life (30 years).

B. Climate Risk Screening

Climate Change Events	Possible Risks
Increased air temperatures (The average temperature rise is projected to be about 1.07 °C in 2030s and 1.82 °C in the 2050s under RCP8.5 scenario)[a]	• Reduced ratings of T&D lines and transformers • Sagging of T&D lines
Precipitation/ Extreme Weather events (Projections indicate rainfall will increase by about 6.4% in 2030s and about by 12.1% in 2050s) (WSDI are projected to increase by 27.6 days by 2030s and 43 days by 2050s under RCP8.5 scenario)[a]	• With the increase of temperature, WSDI also increases leading the infrastructure to risks from GLOFs. Flooded transformers and substations are subject to short circuits, leading to destruction if not shut down in advance. Flooding can undermine tower structures through erosion. The erosion of soil below the foundations can result in tilting of frustums of the tower and cracking of the chimneys. • Overhead lines will be indirectly affected when the towers get impacted due to floods. However, the underground transmission lines will be directly impacted due to these events. • These events can potentially damage underground lines and may lead to total disruption of power supply depending on the magnitude of event. Infrastructure and equipment mounted at ground level in substations are especially susceptible. Flood may enter the substation premises and cause heavy damage to its infrastructure and electrical equipment. Flood can also lead to health hazards.
Cyclones/Winds/Gusts[b] (There is a 1% chance of potentially damaging wind speeds in the project area (Nepal) in the next 10 years)	• The towers can be buckled from stub level or from the top of 1st panel (normal tower) level or from top/bottom cross arm level or peak broken without any damage to lower portion of tower and foundation. The failure of towers could be due to sinking of any of its leg due to uneven distribution of load on tower which may result in shearing of stubs of other legs at concrete level and development of crack in stub of leg.
Landslides/Droughts[b]	• The project's infrastructure is vulnerable to these hazards. • Loss of power supply

	Permanent physical damage to T&D network infrastructure

Note: Short term (2030s): 2016-2045, Long term (2050s): 2036-2065.
Source: [a]: Intergovernmental Panel on Climate Change
[b]: Think-hazard, United Nations Disaster Risk Reduction Facility

Climate Risk Classification: Medium

C. Climate Risk and Adaptation Assessment

1. Primary climate change risks that can impact project in the short to medium term are temperature increase and variability of rainfall, particularly the increases during the monsoon seasons.
2. Long-term climate change risks that could impact project are flooding from extreme rainfall events, particularly during monsoon periods, and increases in average temperature (>35°C) in the project area that could increase the risk of extreme hot days resulting in GLOFs.
3. The de-rating of components is one of the risks due to climate change. This will constrain the power delivery ability of the project and affect system reliability.[2]
4. Although it is not a direct effect of climate change, transmission and distribution grid control system, and therefore power distribution to consumers, become more vulnerable to failure as higher percentages of renewable energy are fed into grids.
5. Adaptation may involve additional investments on design and materials, use/installation of new technologies, and improved operation and maintenance.

D. Climate Risk Screening Tool/Procedure Used:

SARD climate risk screening framework and methodology

ERP = enterprise resource planning, GLOFs = glacial lake outburst floods, km = kilometer, kV = kilovolt, MVA = megavolt-ampere, RCP = representative concentration pathways, SARD = South Asia Department, T&D = transmission and distribution, WSDI = Warm Spell Duration Index,

IV. CLIMATE ADAPTATION PLANS WITHIN THE PROJECT

Adaptation Activity	**Target Climate Risk**	**Estimated Adaptation Finance for EGMP** ($ million)	**Estimated Adaptation Finance for AF** ($ million)	**Total Incremental Cost of Adaptation (Million USD)**	**Adaptation Finance Justification** (Costs are incremental due to additional design / materials.)
Raising plinth height of substation to 1.5 m from 0.5 m	Flooding at Substations	0.078	0.039	0.12	To prevent flooding at substation during high floods.
Raising plinth height of equipment at substation to 1.5 m from 0.3 m	Flooding at Substations	0.0936	0.047	0.14	To prevent water-electricity interaction hazards at substation during high floods.
Constructing 2 m high retaining walls along the substation periphery	Flooding at Substations	0.156	0.078	0.23	To prevent external water entering into substation premises during floods.
Fire wall between transformers	Flooding at Substations	0.02184	0.011	0.03	To prevent hazards during floods.
Cost of infrastructure to withstand 55 m/s windspeed	Cyclones	0.234	0.059	0.29	Increase infrastructure robustness to extreme events.
Protection/ retaining wall for	Landslides, Soil erosion	0.312	0.078	0.39	Increase infrastructure robustness to extreme events such as floods

[2] Reliability here is defined as "the ability to meet the electricity needs of end-use customers, even when unexpected equipment failures or other factors reduce the amount of available electricity." North American Electric Reliability Corporation (NERC). "Understanding the grid: reliability terminology". www.nerc.com/page.php.

Adaptation Activity	Target Climate Risk	Estimated Adaptation Finance for EGMP ($ million)	Estimated Adaptation Finance for AF ($ million)	Total Incremental Cost of Adaptation (Million USD)	Adaptation Finance Justification (Costs are incremental due to additional design / materials.)
foundation of towers in hilly terrain					leading to landslides and soil erosion in hilly terrain.
Pile foundation in flood prone areas	Flooding at towers	0.39	0.098	0.49	Better stability in events of floods
Revetment & use of geo-synthetic material in foundation, concrete encasing & painting of stub in water logging areas	Flooding, soil erosion, land slides	0.0624	0.016	0.08	Increase infrastructure robustness to extreme events such as floods leading to Landslides and soil erosion in hilly terrain
Cost of ACSR Moose conductors	Increase in temperature	0.4212	0.11	0.53	Allow conductors to withstand maximum ambient temperature of 45 °C
Cost of PSC poles and its foundation.	Cyclones, Intense rainfall, flooding	0.05	0	0.05	Increase infrastructure robustness to extreme events
Total cost		**1.8**	**0.53**	**2.35**	

ACSR = Aluminum Conductor Steel Reinforced, , AF = additional financing, EGMP = Electricity Grid Modernization Project, m = meter , PSC = project supervision consultant.

Note: The incremental cost of adaptation measures were estimated based on ADB's Guidance Note on Counting Climate Finance for Energy Sector Projects, available project documents, bill of quantities, discussion with technical design team and previous experiences with ADB on similar projects in energy sector.

V. CLIMATE MITIGATION PLANS WITHIN THE PROJECT

Mitigation Activity	Estimated Greenhouse Gas (GHG) Emissions Reduction (tCO_2e/year)[a]	Estimated Mitigation Finance ($ million)	Mitigation Finance Justification
Renewable Energy penetration into the country.	EGMP: 34716.54 AF: 6736.05 Total: 41452.6	EGMP: 88.9 AF: 26.92 Total: 115.82	This investment will help the Nepal utility to significantly reduce Technical & Commercial losses and thus reducing the emission of the GHG's into the atmosphere. The efficiency improvement and T&D network strengthening will also allow higher the penetration of renewable hydropower by forming stronger interconnection with other regions which are rich in hydropower generation and thereby reducing the use of power from thermal resources.
a: GHG emission calculation details are provided in appendix 6.			

Appendices: Information Used in Climate Risk Screening

Appendix 1: Project Location

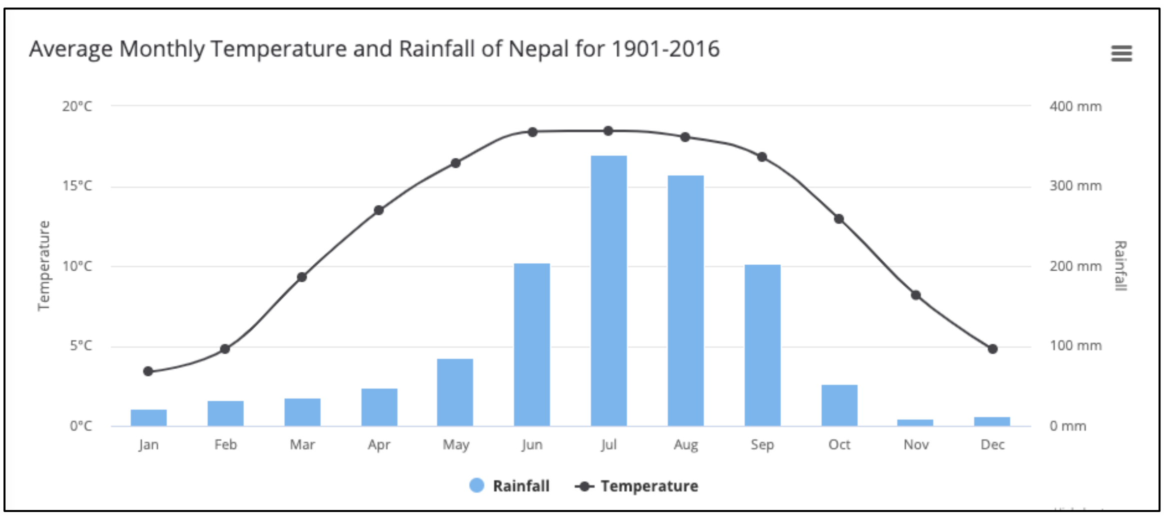
Nepal is a landlocked, mountainous country located in the Himalayas between India and PRC in South Asia. The terrain is generally mountainous and contains many of the world's highest peaks, including Mount Everest (8848 m). However, there are also low-lying areas at elevations less than 100 m. The country is divided into five geographic regions, each with a distinct climate and culture. Rainfall in Nepal is driven by the monsoons, which migrate through the country in the summer months (between June and September) and bring 250–450 mm of rainfall each month to a majority of the country (except for the north-western mountains that receive between 100–150 mm per month). Winters are largely dry in Nepal. Average annual temperature for the whole country is 27°C and average rainfall is 1900 mm annually. However, these statistics vary by region and altitude.[3] The lowland regions of Nepal have a warm and humid sub-tropical climate, with temperature around 22–27℃ in summer months, dropping to 10–15℃ in the winter. The high altitude mountainous regions are considerably colder, at 5–15℃ in summer months, and remaining well below zero in the winter. Monsoon rainfalls arrive in June and continue until August or September, bringing 250–450 mm of rainfall per month in most of the country, but only 100–150 to the north-western mountain regions. The winter months are very dry and all regions receive less than 50 mm per month.

Appendix 2: Hazard and Exposure Profile

The State lies in a seismically active zone V[4], with earthquake impacts. It is also affected by floods, flash floods, landslides and droughts.

Appendix 3: Historical Climate Change Trends[5]

Figure A3.1: Average Monthly temperature and Rainfall of Nepal, 1901–2016



Source: World Bank Climate Knowledge Portal

A recent study by Department of Hydrometeorology Nepal (DHM, 2017) on observed climate trend analysis for the period of 1975–2014 suggests a significant positive trend in annual maximum temperature data at the rate of 0.056 °C/year. All Nepal minimum temperature trend is increasing at the rate of 0.02 °C/year, which is significant during the monsoon season only. The mean temperature data suggests that the average mean temperature is 12°C. The average winter mean temperature is 4.6°C and the average summer mean temperature is 17.7°C. The lower elevation areas are warmer than the mountains.

Table A3.1: Historical average seasonal temperature and rainfall for Nepal during the time period 1981-2010 at location

	Precipitation	Average precipitation	
Seasons	Mean Temperature	mm	%
Winter (Dec-Feb)	4.6	84	5
Pre-monsoon (Mar-May)	12.5	232	13

[3] Global Facility for Disaster Reduction and Recovery, World Bank, Washington, DC. *Nepal: Vulnerability, Risk Reduction and Adaptation to Climate change*.
[4] http://drrportal.gov.np/risk-profile-of-nepal.
[5] National Adaptation Plan for Nepal. Government of Nepal.

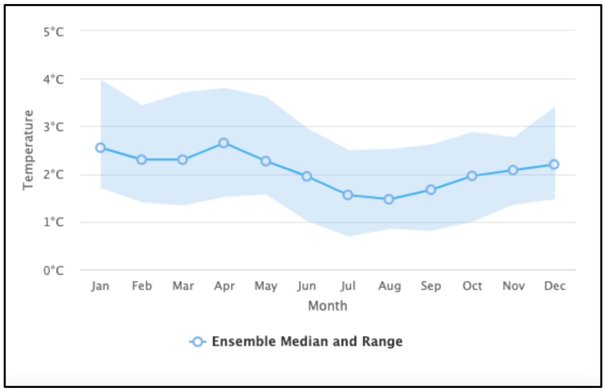
Regarding change in precipitation, however, there is still a lack of a clear trend. One study found that there were no distinct trends in precipitation in the Nepal between 1959 and 1994 (Shrestha et al., 2000). Using data from 1961–2006, another study found an increasing trend in total and heavy precipitation (Baidya et al., 2008).

Monsoon (Jun-Sep)	17.7	1418	77
Post-Monsoon	11.4	96	5
Annual	12.1	1830	100

Source: Department of Hydrometeorology Nepal, Government of Nepal (2017)

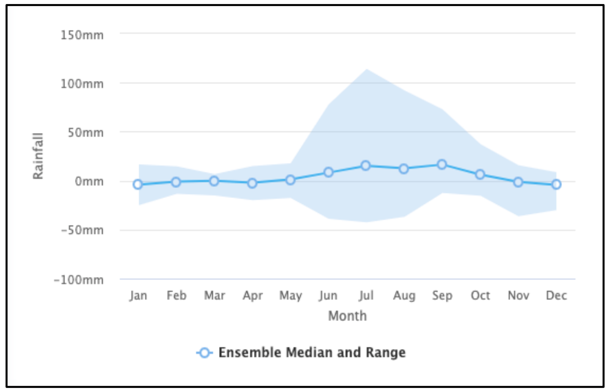
Appendix- 4: Projected Climate Change and Whether Extremes[6]

Figure A4.1: Projected temeperature changes for **2050s** for **RCP 8.5** emission scenario



Source: World Bank Climate Knowledge Portal

Figure A4.2: Projected precipitation changes for **2050s** for **RCP 8.5** emission scenario



Source: World Bank Climate Knowledge Portal

For RCP 4.5, in the 2030s (medium-term), the average annual mean temperature change is projected to increase by 0.92 °C, whereas, in the 2050s (long-term), it is likely to increase by 1.3 °C in average whereas for RCP8.5, in the medium-term period, the average temperature change is projected to be 1.07 °C warmer whereas, in the long-term period, it is likely to be 1.82 °C warmer in average.

In the medium-term period, the average annual precipitation change is projected to increase by 2.1%, whereas, in the long-term period, it is likely to increase by 7.9% for RCP4.5. For RCP8.5, average annual precipitation change is projected to increase by 6.4% in the medium-term period and 12.1% in the long-term period. However, there is a spatial variation of projected changes in which the central and western regions are likely to be wetter than the eastern. Precipitation is likely to increase in the central and western parts in both the short-term and the long-term periods.

Table A4.1: Projected change in monthly temperature (ºC) and rainfall (mm) for 2030s, 2050s and 2080s, compared to the reference period (1981–2010)

Change in Temperature (°C)			
RCPs	2030s	2050s	2080s
RCP 4.5	0.92	1.3	1.72
RCP 8.5	1.07	1.82	3.58
Change in Precipitation (%)			
RCP 4.5	2.1	7.9	10.7
RCP 8.5	6.4	12.1	23

Source: IPCC

[6] Future climate information is derived from 35 available global circulation models (GCMs) used by the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report. Data is presented at a 1x1 global grid spacing, produced through bi-linear interpolation. Values are for the RCP8.5 Scenarios. World Bank India Climate Data.

Frequency of Warm Days: In the medium-term period, warm days are likely to increase across Nepal, with the eastern part registering an increase by a higher magnitude and the warm days will increase by 64.5% (23.9 days) for RCP4.5 and by 71.4% (26.4 days) for RCP8.5. In the long-term period, the eastern part of Nepal will be affected more by the increase in temperature, as the increase is expected to be 87.3% (32.3 days) and 124.7% (46.1 days) for RCP4.5 and RCP8.5, respectively.	**Frequency of very wet days:** The percentage change in annual total days when the precipitation is higher than 95 percentile (P95), indicating very wet days for the reference period are 18.1. In the medium-term period, the very wet days are likely to increase in the eastern and central regions (in RCP4.5) and in the western and central regions (in RCP8.5). Overall, the increase is about 1.5% (0.3 days) for RCP4.5 and about 12.1% (2.2 days) for RCP8.5. In the long-term period, the increase is mostly concentrated around the central region. The projected increase is about 12% (2.2 days) for RCP4.5 and 18.6% (3.4 days) for RCP8.5.

Table A4.2: Change in extreme weather indices in the medium-term and the long-term periods

Indices	No. of mean annual days in the reference period	RCP4.5				RCP8.5			
		2030s		2050s		2030s		2050s	
		%	days	%	days	%	days	%	days
Very wet days (P95)	18.1	1.5	0.3	12	2.2	12	2.2	18.6	3.4
Extremely wet days (P99)	3.5	26.3	0.9	41.3	1.4	28	1	59.8	2.1
Rainy days	166.4	-1.8	-3	-1	-1.7	-0.9	-1.6	-0.5	-0.8
Consecutive Dry Days	45.3	6	2.7	2.4	1.1	-1.6	-0.7	-2.9	-1.3
Consecutive Wet Days	78.1	-4.2	-3.3	-1.3	-1	3.1	2.5	2.2	1.7
Warm days	36.5	64.5	23.9	87.3	32.3	71	26.4	125	46.1
Warm nights	36.5	81.4	30.5	115.7	43.3	101	37.8	159	59.6
Cold days	36.5	-42	-15.4	-52.6	-19.3	-56	-20.5	-75	-27.5
Cold nights	36.5	-40.7	-15	-53.5	-19.7	-54	-19.9	-74	-27.3
Warm spell duration index	17.6	110	19.3	149	26.2	157	27.6	245	43
Cold spell duration index	20.3	-51.8	-10.5	-63.9	-12.9	-55	-11.2	-73.3	-14.8

Appendix- 5: Climate Change Financing[7]

Table A5.1: Climate mitigation Financing

Sl. No	Project Component	ADB Financing	Percentage considered for Climate Mitigation[37]	Climate Mitigation Finance	Justification for Climate Mitigation Finance
I	**EGMP Project**				
1	**Transmission Reinforcement**				
A-2	Construction of Dandakhet - Rahughat 132 kV Transmission Line and associated substations at Dandakhet and Rahughat	24.0	62.75%	15.1	The project will allow increased penetration of renewable energy generation into the grid, allowing greater displacement of fossil-generated electricity. The entire share of renewable
A-3	Construction of Ghorahi - Madichaur 132 kV Transmission Line and	10.5	62.75%	6.6	

[7] Climate change mitigation costs and incremental cost of adaptations were calculated based on “Guidance Note on Counting Climate Finance at ADB (2017) and Guidelines for Climate Proofing investment in Energy sector (2013).”

	associated substation at Madichaur				energy (62.75%) evacuation is considered as mitigation for these project components as per the list of eligible mitigation activities under ADB's Guidance Note on Counting Climate Finance in Energy.[a]
A-5	Construction of Borang - Lapang 132 kV Transmission Line, Lapang - Ratmate 220 kV Line and associated substations at Borang and Lapang	24.9	62.75%	15.6	
B-1	Construction of 132/33/11 kV substation at Pangtang, Sindhupalchowk	4	62.75%	2.5	
B-2	Construction of 132/33/11 kV substation at Surkhet	4.7	62.75%	2.9	
B-3	Construction of 132/33/11 kV substation at Keraun, Morang	6.5	62.75%	4.1	
C-1	Grid substation Automation (Outside Kathmandu Valley)	14	100%	14	Mitigation CF is 100% (default value) of ADB funding for this component being smart grid element project.[a]
D-1	132 kV / 66 kV Transmission Line Conductor Upgradation	15.8	40.00%	6.3	Mitigation CF is 40% (default value) of ADB funding for this component. This component expands the capacity which may result in loss reduction. The 40% factor represents the conservative percentage of total benefits that go to energy savings in recent ADB's T&D projects.[a]
	Subtotal (1)	**104.4**		**67.1**	
2	**Distribution Modernization**				
C-2	Construction of Distribution Command and control centre	11.1	100%	11.1	The project will allow increased penetration of renewable energy generation into the grid, allowing greater displacement of fossil-generated electricity. This being the smart grid element, default value of 100% for climate finance considered. as per the list of eligible mitigation activities under the Guidance Note on Counting Climate Finance in Energy.[a]

C-3	Smart metering in Kathmandu Valley	35.7	30%	10.7	Mitigation CF is 30% (default value) of ADB funding for this component. This component will result in reduction of commercial losses.[a]
	Subtotal (2)	**46.8**		**21.8**	
3	Consulting Services	**1.5**	0.00%	**0**	
	Total Base Cost (a)	**152.70**		**88.9**	
	Project Support Cost				
	Contingencies	0	0%	0	
	Financing Charges During Implementation	3.3	0%	0	
	Total Support Cost (b)	**3.3**		0	
	Total	**156**		**88.9**	
II	**EGMP Additional Financing**				
1.	**Transmission Reinforcement**				
A-1	Construction of Kohalpur - Nepalgunj 132 kV transmission line and associated new substation at Nepalgunj	8.8	62.75%	5.54	The project will allow increased penetration of renewable energy generation into the grid, allowing greater displacement of fossil-generated electricity. The entire share of renewable energy (62.75%) evacuation is considered as mitigation for these project components as per the list of eligible mitigation activities under the Guidance Note on Counting Climate Finance in Energy.
A-2	Construction of 132 kV underground line from Chobar to Lagankhel and augmentation of Lagankhel substation	18.9	62.75%	11.83	
B-1	Construction of 132/33/11 kV substation at Mulpani	9.4	62.75%	5.91	
B-2	Construction of 132/33/11 kV substation at Dumkibas, Nawalparasi	5.8	62.75%	3.64	
	Subtotal (1)	42.9	62.75%	26.92	
2.	**Distribution Modernization**				
D-1	ERP and Revenue Management System	15.0	0%	0.00	
	Subtotal (2)	15.0	0%	0.00	
3.	**Other Costs**				
a.	Consulting Services				
i.	Project implementation support	1.0	0%	0.00	

	Subtotal (a)	1.0	0%	0.00	
Total Base Cost (1+2+3)		**58.9**		**26.92**	
	Contingencies				
i.	Physical	0.0	0%	0.00	
ii.	Price	0.0	0%	0.00	
Financing Charges During Implementation		1.1	0%	0.00	
Total Project Cost		**60.0**		**26.92**	

As per NEA's latest annual report (2018–2019), out of the total available energy, NEA's own generation contributed 33.75%, whereas those imported from India and domestic Independent Power Producers accounted for 37.25 % and 29.00 % respectively. There total share of Nepal RE production is 33.75+29=62.75 % is considered as climate finance for new substations and transmission lines.
For conductor upgradation, a default value of 40% is considered as climate finance to be on conservative side.
For Smart Metering, a value of 30% is considered as climate finance.
[a] *Guidance Note on Counting Climate Finance in Energy Sector* at ADB (2017).

Table A5.2: Incremental Cost of Adaptation

Sl. No	Component	Total Cost of Project (Million USD)	Incremental Cost of Adaptation for EGMP Components (Million USD)	Incremental Cost of Adaptation for AF components (Million USD)	Total Incremental Cost of Adaptation (Million USD)
1	Raising plinth height of substation to 1.5m from 0.5m	156 (EGMP) + 60 (AF) = 216	0.078	0.039	0.12
2	Raising plinth height of equipment at substation to 1.5m from 0.3m		0.0936-	0.047	0.14
3	Constructing 2m high retaining walls along the substation periphery		0.15600	0.078	0.23
4	Fire wall between transformers and other equipment		0.02184	0.011	0.03
5	Incremental Cost of Towers to withstand 55m/s windspeed		0.23400	0.059	0.29
6	Protection/ retaining wall for foundation of towers in hilly terrain		0.31200	0.078	0.39
7	Pile foundation in flood prone areas		0.39000	0.098	0.49
8	Revetment & use of geo-synthetic material in foundation, concrete encasing & painting of stub in water logging areas		0.06240	0.016	0.08
9	Incremental Cost of ACSR MOOSE conductors		0.42120	0.110	0.53
10	Incremental cost of PSC poles and its foundation (Distribution line)		0.04680	0	0.05

	Total adaptation cost		**1.82**	**0.53**	**2.35**

Table A5.3: Total Climate Financing Cost

Project	Incremental cost of Adaptation (Million USD)	Climate Mitigation Finance (Million USD)	Total cost of Climate Financing (Million USD)
EGMP	**1.82**	**88.9**	**90.7**
AF	**0.53**	**26.92**	**27.45**

Appendix- 6: CO_2 emission calculations

Table A6.1: CO_2 Emissions Reduction

		EGMP Project Component	AF Project Component	
. From Reduction in Technical Losses				
Total Domestic Supply in 2018	GWh/year	4476.00	4476.00	Source: https://www.adb.org/sites/default/files/linked documents/50059-003-cca.pdf
Total Import Supply in 2018	GWh/year	2581.80	2581.80	
Total Available Energy in 2018	GWh/year	7057.80	7057.80	
Energy Saving (Loss Reduction)	GWh/year	162.33	162.33	Considering target to 13% compared to baseline of 15.3%
Total consumer	Nos.	3909641	3909641	NEA's Annual Report for 2018/19
Total consumers benefitting from the project	Nos.	134000	26000	PAM
Share of the project	%	3.43	0.67	Considering target beneficiary customers among total
Energy Saving (Loss Reduction) for the project	GWh/year	5.56	1.08	
Emission Factor	tCO2e/MWh	0.92	0.92	Emission factor India assuming it will replace import
Emission Reduction	tCO2e/year	5118.62	993.17	

	II. From Increase in Power Consumption			
(A) Per capita electricity consumption in 2018	kWh/ capita	198.0	198.0	
(B) Per capita electricity consumption by 2027	kWh/ capita	700.0	700.0	
(B-A) Incremental Increase in electricity consumption	kWh/ capita	502.0	502.0	
Total consumers benefitting from the project	Nos.	134000	26000	PAM
Total energy consumption	GWh/year	67.27	13.05	Considering per capita incremental increase of 502 kWh/year
Emission Factor for Nepal	tCO2e/MWh	0.043	0.043	Source: https://unfccc.int/sites/default/files/resource/Harmonized_Grid_Emission_factor_data_set.pdf
Emission Factor for India	tCO2e/MWh	0.92	0.92	Combined margin emission factor for India
Emission Factor for Nepal (domestic + import)	tCO2e/MWh	0.36	0.36	https://www.adb.org/sites/default/files/linked-documents/50059-003-cca.pdf
Baseline emission factor (diesel)	tCO2e/MWh	0.80	0.80	https://www.adb.org/sites/default/files/linked-documents/50059-003-cca.pdf
Emission Reduction	tCO2e/year	29597.92	5742.88	
Total emissions reduction	tCO2e/year	**34716.54**	**6736.05**	

kW = kilowatt, kWh = kilowatt-hour, GHG = greenhouse gas, GWh = gigawatt-hour, MWh = megawatt-hour, RE = renewable energy, tCO2e = tons of carbon dioxide equivalent.