CLIMATE CHANGE ASSESSMENT, IMPACTS OF GLOBAL WARMING, PROJECTIONS AND MITIGATION OF GHG EMISSIONS ENDORSING GREEN ENERGY

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ABSTRACT

Climate change, an emerging global issues concern to ongoing rise in global average temperature by increasing concentrations of greenhouse gases in the atmosphere. The large amount of greenhouse gases and trapping energy into the atmosphere cause an effects to human health and ecosystems or life supporting system on the earth. Verified claim of global warming by the heat trapping gases like CO2 emitted from fuel combustion has increased atmospheric CO2 in the earth above 60% from 1990 resulting increases on an average global temperatures 1oC since 2001 to 2015. IPCC projections in 2014 showed 2. 6ºC global warming by 2100 compared to 1850-1900 and more chances to exceed 3ºC by 2100. Sequential climate change projections like, GCMs, SDSM, RCMs, LAMs adopted with IPCC technical assistance and UNFCCs developed tools/methods for vulnerability and adaptation to climate change impacts, further driven climate model simulations RCPs, all methods projected global mean temperature rise by 0.3 to 4.8°C by the late 21st century. As cumulative anthropogenic CO2 emissions in the atmosphere between 1750 and 2011were 2040 ± 310 GtCO2, Conference of the Parties (COP) of UNFCC 2010 agreed to limit global warming below 2.0°C (3.6°F) and below 1.5°C relative to the pre-industrial level in the Paris Agreement and mitigation includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks. The large uses of fossil fuel based energy like Coal, Oil and Gas has extremely increased CO2 emission globally together with rapid population growth which can be reduced through promotion of renewable energy. Hydropower a clean energy generation is 16.6% in 2015 out of world's total electricity and 70% of all electricity generated represents 20% from hydropower which emits 35 to 70 times less GHGs per TWh than thermal power plants. Hydropower development a source of cost-effective and low-carbon renewable energy adopted about 160 countries with capacity of 1209 GWe generates about 3500TWh per year along in Asia with 542GW installed capacity and 2,204 GW potential. Nepal a country of southeast Asia has 63 projects in operation till November 2017 with 907.509MW installed capacity with contibution of low (1.67%) CO2 emmission in compare to 98.33% annaul reduction of carbon emmission estimated from disel/oil in the atmoshphere.

Keywords: Climate Change, GHG Emissions, Impacts, Projections, Clean Energy, Hydropower.

1. Introduction

The changes in global temperature, precipitation, monsoon, wind patterns and other consequent effects occurring over several decades or longer periods of time refers climate change. The ongoing rise in global average temperature by increasing concentrations of greenhouse gases in the atmosphere is the major concern of climate change. The large amount of greenhouse gases releases into the atmosphere from burning fossil fuels, deforestation, industrial processes and agricultural, trapping energy in the atmosphere and cause an effects to human health and welfare and to ecosystems or life supporting system on the earth. This significant warming trend likely to human induced and proceeding at a rate has unprecedented in the past 1,300 years (1) (2) (3) (4). Since 1896,Svante Arrhenius, claim of global warming from fossil fuel combustion and relation between atmospheric carbon dioxide concentrations and temperature, heat trapping gases like CO_2were verified in mid-19th century[2]. The earth's climate responds drowning ice cores, Antarctica and tropical mountain glaciers changing greenhouse gas (5) levels showed the Earth has warmed since 1880[3], and ultimately rose sea level about 17 centimeters (6.7 inches) in the last century (6).

Since 2001, warming increasing repeatedly as global average temperatures in 2015 were 1 degree Celsius or more above the 1880-1899[4] (7) and much of this increased heat absorbed the oceans, with the top 700 meters (about 2,300 feet) of ocean showing warming of 0.302 degrees Fahrenheit since 1969 (8). The rapid declining of Arctic sea ice both the extent and thickness, over the last several decades (9) and retreating of glaciers i.e. the Alps, Himalayas, Andes, Rockies, Alaska and Africa around the world[5]. The increasing acidity of surface ocean waters by about 30%[67],is the result of more release of CO_2 in the atmosphere and observed in the Oceans increasing by about 2 billion tons per year (10)[,8]. The satellite observations of decreased snow cover in the Northern Hemisphere over the past five decades results that earlier melting of the snow[9] (11).

The use of fossil fuel emissions globally showed 9.795 gigatonnes (Gt) in 2014 (or 35.9 $GtCO_2$ of carbon dioxide) which were 0.6% more than 2013s emissions and 60% above from 1990s (the reference year of Kyoto Protocol)[10].

As a primary source of CO_2 is fossil fuels, atmospheric CO_2 in the earth observed the daily 404.90 ppm CO_2 in December 30, 2016 which was recorded 402.89ppm in 2015 according to the global carbon project. The total 91% CO_2 emissions accounted in 2014 from fossil fuel originated emitting from coal (42%), oil (33%), gas (19%), cement (6%) and gas flaring (1%) and all global CO2 emissions responsible to land use changes about 9% of total changes. From 2005 to 2014, 44% of CO2 emissions accumulated in the atmosphere globally and about 545 GtC in totaled and emissions were partitioned among the atmosphere (approx. 230 GtC or 42%), ocean (approx. 155 GtC or 28%) and the land (approx. 160 GtC or 29%) cumulative carbon were emitted from 1870 to 2014 (12), (13) (14).

The Methane (CH4) emissions a GHG gases produced from agricultural activities, waste management, energy use, and biomass burning and Nitrous oxide (N2O) also produced from agricultural activities like use of fertilizer or biomass burning. From industrial processes, refrigeration, and the use of a variety of consumer products contribute to emissions of F-gases, Fluorinated gases (F-gases) generated including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6).

CO2 emissions in Asia and the Pacific as a whole will increase from 13,404.0 million tons of CO2 in 2010 to 22,112.6 million tons of CO2 in 2035 at a growth rate of 2.0% per year which will be slightly slower than the projected growth in energy demand of 2.1% per year (15). The cumulative CO2 emission represents concentrated pathways 2.4 trillion tons RCP 4.5 from 2011 to 2100 (16). This leads CO2 equivalent of 650 parts per million by 2100 to atmospheric concentration which resulted 2.6 degrees Celsius global warming by 2100 (compared to 1850-1900), and more chances to exceed 3ºC by 2100 (16). The assessment of CC projection, shows increasing 2ºC temperature rise sea level by 5-9 meters over the next 50-200 years, melting cause of West Antarctica ice sheets (17). The major coastal cities like Bangladesh, European lowlands, the US eastern coast, North China plains will be submerged. World carbon dioxide emissions in energy sectors rise from 32.2 .2 billion metric tons in 2012 to 35.6 billion metric tons in 2020 and to 43.2 billion metric tons in 2040 which is 34% over the projection period (18). The emission ration will be more in developing countries and non OECED project emissions will be 51% higher total about 29.4 billion metric tons in 2040 than 2012 level and about 9% higher than 2012 total 13.8 billion metric tons from OECD emissions in 2040 (19).

The emissions of carbon threats basic elements of society like water, food production, health and the environment imposing a huge social cost as anywhere from $8 per ton to as high as $100 per ton of CO2. The main source of CO2 generation, more than 50% of the emissions from fossil fuel combustion for transportation and electricity generation and 66% from thermal power plants, which is the world's electric generation capacity. However, the hydropower represents only 20% electricity generation capacity of the world, which emits 35 to 70 times less GHGs per TWh than thermal power plants (20).

BP Statistical Review of World Energy 2017 reported hydroelectricity consumption in 2016 in Asia Pacific was 368.1 and 910.3 Million tonnes oil equivalent total in the world and emmission of 16100.5 Million tonnes of CO2 in the Aisa Pacific and 33432.0 total in the world in 2016. Establishing the renewable energy around the world together aimed with reduction of GHG, Nepal has also established hydropower sector to mainstream sources of clean energy targeting production of its 45,610 MWs economic potential. Consiquently, promotion of renewable energy can help to reduce high carbon emission replacing petroleum products to the extent possible in transport, industry, and household sectors.

2. Material and Methods

Climate change impacts are the affecting system of secondary and tertiary consequences on human or natural systems. There are several methods and tools used for impact assessments of climate change. General Circulation Model (GCMs), a computer models mathematically represent various physical processes of the global climate system. As an Intergovernmental Panel on Climate Change (IPCC), 2007 has readily available climate change projections at global and cont initial spatial scales for the end of the 21st century, variety of methods with their own merits and limitations to be used for future climate change projection.

2.1. Literature Review

Review of literature resembles sources of information drag out from published research reports, project documents (reports, articles and plans), online toolkits, compendia and databases. For this paper climate change, impacts, prediction and renewable energy related toolkits, project documents, IPCC assessment reports, research publications; working papers, legal texts, including agreements, treaties and policy documents; and promotional material from private stakeholders and organizations were reviewed, analyzed, discussed and documented.

2.2. Climate Change Impact Assessment and Projections

Statistical Down Scaling Model (SDSM): Statistical Downscaling Model (SDSM) used to spatially downscale daily predictor predict and relationships (21) and it provides locally available data adequate to calibrate the model archiving with GCM output (22). For large-scale variables for future climate change, key input data for both local-scale and large-scale climate variables and daily GCM outputs (UNFCCC, 2013) which can also be used in climate impacts with site -specific daily scenarios for maximum and minimum temperatures, precipitation, and humidity. It also produced series of statistical parameters such as variance, frequencies of extremes, and spell lengths (23).

Smith et al., (1992) had interpolated based on linear averaging by the inverse of distances between the specific point and the GCM grid points (24). Similarly statistical methods for generating greater data use of high resolution regional climate models (RCMs; also called limited area models, LAMs) downscaling techniques are appropriate. Much finer resolution than GCMs (often 50 kilometers), regional climate models are developed with limited to continents or subcontinents. Global Climate Models (GCMs) which use mathematical equations to describe the dynamic of climate system for projections of future climate.

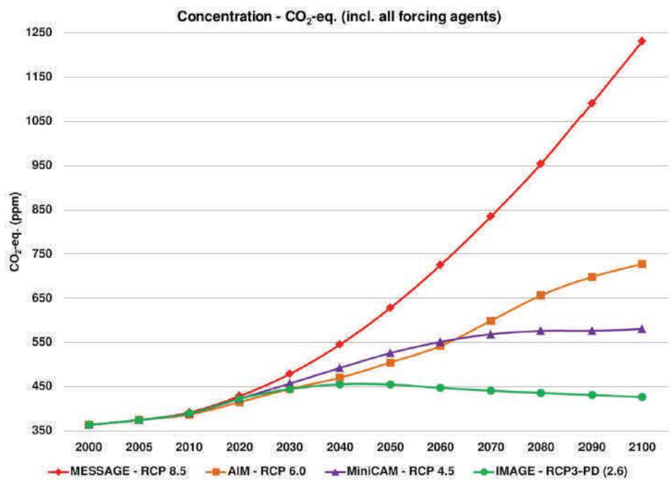

Figure 1: Representative Concentration Pathways (RCPs) are the four greenhouse gas concentration trajectories adopted by the IPCC for its fifth assessment

For the evolution of atmospheric composition, Representative Concentration Pathways (RCPs) has introduced to provide a range of possible futures scenarios of climatic (25) (26). The RCPs used to drive climate model simulations, RCP8.5 corresponds to the pathway with the highest greenhouse gas emissions and developed Integrated Assessment Framework and the MESSAGE model for the development of the RCP8.5 encompassing detailed representations of the principal GHG emitting sectors- energy, industry, agriculture, and forestry.

The fifth Assessment Report (AR5) 2014 adopted Representative Concentration Pathways (RCPs) for four greenhouse gas concentration and used for climate modeling and research (27) (Fig.1). They describe four possible climate futures, all of which are considered possible depending on how much greenhouse gases are emitted in the years to come. The possible climate features of emitted green house gas years to come ranging values of +2.6, +4.5, +6.0, and +8.5 W/m^2 pre-industrial level in the year 2100 with possible range of radiative forcing values relative to values using RCP2.6, RCP4.5, RCP6, and RCP8.5 (28). The atmospheric GHG concentration RCP 2.6 assumes peak between 2010-2020 with emissions declining substantially thereafter and peak around 2040 than decline as per RCP 4.5, emissions peak around 2080, then decline under RCP 6 and emissions continue to rise throughout the 21st century in RCP 8.5 (29). The global mean temperature projected these entire RCPs rise by 0.3 to 4.8°C by the late-21st century.

Promotion of green energy to reducing GHG emissions

Greenhouse gases (GHGs) have different effects and act like a blanket insulating the Earth warming by absorbing energy and slowing the rate at which the energy escapes to space. To compare global warming impacts of different gases, Global Warming Potential (GWP) has developed. As the measurement of GWP is the energy of the emissions of 1 ton of a gas, which absorbed from selective time period usually 100 years and relative to the emissions of 1 ton of carbon dioxide CO2. To compare emissions reduction opportunities across sectors and gases, GWPs allows analysts and policy maker to add up emissions estimates of different gases (e.g., to compile a national GHG inventory) as unit measures. The climate change with four multiple scenario of physical effects and economic damages of climate change can be quantified or measured with the Climate Change Impacts and Risk Analysis (CIRA) which support to estimate degree of climate change impacts and damages concerning sectoral effects on human health, infrastructure, and water resources. The changes and rising temperatures, shifting of snow and rainfall patterns together with heavy rainstorms and record of high temperatures as shifting with more extreme climate events, CO2 and GHG gases climbing in our atmosphere due to burning fossil fuels for energy and other activities of humans.

Mitigation and Adaptation

An anthropogenic intervention to reduce the anthropogenic forcing of the climate system includes several developed strategies to reduce greenhouse gas sources and emissions enhancing greenhouse gas sinks. The SCOPE Report on Impact Assessments is the major documents developed for such assessments (30). The other supporting documents of impact assessment for synthesized and guided are: IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations (31); the US Country Studies Program's Vulnerability and Adaptation Assessments: An International Guidebook (32) and the Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies (33).

Climate change assessment resulted to adopt adaptation strategies to be designed in different sector and Compendium of Decision Tools to Evaluate Strategies for Adaptation to Climate Change (34) later focused on decision-making under sectoral approach and decisions based impact assessment, adaptation and vulnerability assessments. For climate adaptation Willows and Connell 2003 has emphasized Risk, Uncertainty and Decision-making with uncertainty (35) and Adaptation Policy Framework of UNDP 2004 offered an approach for adaptation strategies (36), policies and measures for project basis formulation and implementing with theoretical discussion on adaptation. The updated version of UN Framework Convention on Climate Change

(UNFCCC) 1999, a Compendium of Methods and Tools to Evaluate Impacts and Vulnerability and Adaptation to Climate Change. UNFCCC 2004 has focused solely on impacts to recognizing the centrality of vulnerability (37). Similarly, practical application for emerging issue on climate change, a Guidebook for Local, Regional and State Governments (38) Climate Change Adaptation by Design (39) and formulated similar documents for particular cities targeted at local governments. Adapting to Coastal Climate Change, a Guidebook for Development Planners (40) and various collections of methods and tools, such as the updated Compendium on Methods and Tools to Evaluate Impacts of, and Vulnerability and Adaptation to, Climate Change (41), serve as comprehensive reference documents on adaptation methods and tools (42).

Calculation of CO2 Emission

Combustion of fuels in stationary (non-transport) combustion sources emits carbon dioxide (COR2R), methane (CH4), and nitrous oxide (NR2RO) gases where COR2R accounts for the majority of the GHG emissions from stationary combustion sources. is performed with a Continuous Emissions Monitoring System (CEMS) a method for Direct measurement of COR2R emissions. Following are the methods to describe more in detail about calculation of COR2R emission:

$$\text{Co2 Emission Factor}\left(\text{Tons}\frac{\text{CO 2}}{\text{kWh}}\right) = \frac{\text{Vol.fuelconsumed}}{\text{Mwhoutput}*} X \frac{\text{kgC}}{\text{TJ}*} X \frac{\text{TJ}}{\text{vvolunitoffuel}} X \frac{\text{1tonc}}{\text{1kgC}} X \frac{\text{44g/moleCO 2}}{\text{12g/moleC}} \quad \text{......(1)}$$

Plant based- actual data , Carbon emission factor, per fuel type – IPCC, Net calorific value, country specific, per fuel type (43).

Co2 Emission (tons CO2)=Power Generation (MWh) X Emission Factor (Tons CO2/MWh) X Power Generation (MWh) = Installed Capacity X Plant Capacity X 8760 hours in a year... (2)

Total CO2 Emissions (tons CO2) = Σt Op * Pt*CEFt ……………… (3)

Where, Σt Op =Total electricity generation

Pt =Percentage contribution to grid (%)

CEFt =Emission factor for specific technology and or fuel type (tons CO2/MWh)

Total CO2 Emissions = Σt Op * Pt*CEFt = Op Σt Pt*CEFt =Op* CEFwt.ave

……………….(4)

Accordingly, the general equation to calculate carbon emission from different end use sectors is as follows (IPCC, 1996) (44):

Carbon emission = Σ fuel consumption of each sector X carbon emission factor –Carbon stored X fraction oxidize... (5)

The general equation to calculate emission of non-CO2 gases is as follows (IPCC, 1996):

Emission =Σ (EFab x Activityab)……………….. (6)

Where, EFab denotes emission factor (kg/TJ) and Activity ab denotes energy input (TJ) using fuel type 'a' in sector type 'b'.

Clean Energy Development: A Case Study of Hydropower

Global energy production from fossil fuels like coal, oil and natural gas and its use for transportation, residental, induustrial and other purposes has a significant problem an increasing concentrations of greenhouse gas in the atmosphere. To address this problem use of alternative energy as carbon-free energy for replacement of fossil fuels is vital global issue. Use of environmental friendly source of energy for suistainable development, several researchers highlighted the issue i.e. Nakata et al., (2011:465) described 'low-carbon society (45), Bilen et al., (2008:1531) 85% described predicted demand increased by 2030 (46), significant energy security and economic benefits (47) countries strategy addressed in Kyoto Protocol 1997 to begin plan and diversify their energy portfolio resources, IPCCs integrating a portfolio of renewable energy technologies and much faster adovocacy (48) and promotion of renewable energy methods like Hydroelectricity is suistainable (49).

Mesurement and studies of GHG emmission from artificial lakes (50) nutrient inflow in water system growing plants and plankton (51), accurate estimation of the net emissions from aquatic ecosystems GHG emmsions depending upon climatic, surface area, water depth and topography (52), methane emissions from RoR type of hydropower (53) and numerous energy sources CO_2 emissions per unit of electricity generated, found that the CO_2 emission values that fell within the 50th percentile of all total life cycle emissions studies by IPCC 2011 (54) all had been studied previousely.

Table1: Lifecycle greenhouse gas emission estimates (55) for electricity generators

Technology	Description	Estimate (g CO_2/kWh$_e$)
Hydroelectric	3.1 MW reservoir	10
Hydroelectric	300 kW run-of-river	13
Fuel Cell	hydrogen from gas reforming	664
Diesel	various generator and turbine types	778
Heavy oil	various generator and turbine types	778

3. Result and Discussion

3.1. Climate Change Impacts

Climate change effects on entire global ecosystem directly influence the natural ecosystem, human kind and wellbeing. From retreating glaciers, melting polar ice caps, extinction of vegetation and wildlife, rising sea level, change in weather pattern, drought to natural disasters all concerns effects of global warming. Thus, global warming has massive impact on natural, biological, social, economic and physical environment. Following table clearly demonstrated the impact of global warming.

Table 2. Impact and implications of Global Warming

Effects of GW	Likely Impacts	Implications
Melting of Glaciers	Sea level raise, flooding, fast retreating of glaciers	Ecosystem imbalances, Glacization
Irregular weather patterns	Increase precipitation and rainfall, changing phonology (56)-Thackeray et al. (2010)	Crop variation and decrease numbers of flora and fauna and increase migration
Droughts	Flooding	Water scarcity
Diseases	Human health, malnutrition	Spreads water borne diseases
Hurricanes Frequency	Oceans rises	Stronger storms
Sea levels rise	Melting of polar ice-caps and less water evaporating into the atmosphere	Devastating flood damage, Inundation of coastal wetlands
Agriculture	Effects on plants growth and survival	Food shortage
Heat waves	Dangerously hot weather	Increase in number, length, and intensity
Frequent wildfires	CO_2 release suffers lives with danger and wildlife severely aches	Less oxygen and species extension
Severe precipitation	Poses severe flooding.	Impacts on human livelihood and wildlife
Longer/shorter seasons	Not enough precipitation to provide adequate nourishment for crops.	Loss of economy
Crops	Major inflation and more economic woes.	Less production
Oceans	Once coral reefs are affected, entire ecosystems that thrive become obsolete	Severely affects aquatic life Increase flooding and storms
Food chain	Series of events disrupted and collapse animal life.	Change and disrupt food chain, risk for extinction, rapid changes in their ecosystems
Health risks	Respiratory diseases and symptoms.	Increase causal death
Animal extinction	Vast eruption in the animal kingdom	Enormous species extinct
Quality of life	Disrupted and disturbed	Adaptation difficulties
Economic collapse	Decreased vitality of crops, productions, and manufacturing item	Hunger problems
Air quality	Health risks	Causal death with severe diseases
Decreased population	Diminish half of the earth's population	Illnesses, starvation, and poverty.
Human extinction	Domino effect	Collapse human identity
Going off the grid	Hits to crumble our electrical system	Large damage across, Failure of grid
Fresh Water	Diminish fresh water supply	Demise of coral reefs and ecosystem
Disappearing Countries	Countries deteriorating at a highly elevated rate	Sink cities or continents into the Sea

The biodiversity of the earth continuously transformed by changing climate and dramatically affected by human alterations of ecosystems (57). Global ecosystems and species directly affected by the climate change and interacts human stressors as development which brings dramatic ecological changes posing cumulative impact (58). The distribution and abundance of aquatic ecosystem is affected by the climate change as 70% of the earth's surface is covered by water. Watson et al. 2000, clearly mentioned that the deforestration a major cause of climate change has long term implications on agriculture, forestry, biodiversity, landscapes and human wellbeing (59).

The major impacts on terrestrial species and habitats are associated with changes in range or phenology, species changes, significant decoupling migration, limits to population growth, disruption of pollination processes and Phenological changes. The long term future implications of shift are grasslands to desert conditions, open forests to grasslands, significant closed forest areas to open forests, alpine areas to closed forest, loss of habitats such as vernal / ephemeral wetlands that are maintained by run-off or rainfall waters and don't have a permanent water source and potential for massive disruptions as ecosystems adjust to new disturbance regimes over the coming decades (re-alignments of ecosystem components, structure and function due to exposure to new disturbance factors and patterns). However, Global climate change effects on ecosystems and ecosystem components have exposure, sensitivity and adaptive capacity. Similarly, changes in habitat availability and distribution will affect population dynamics, and the functioning of larger meta populations. Loss of high quality habitat (or general lowering of habitat quality across the board) may result in a higher chance of local extirpation, or extinction due to loss of source populations or higher distribution of sink populations including sudden population crashes with unexpected result.

A critical component of the global environment, aquatic ecosystems has essential contributors to biodiversity and ecological productivity providing variety of services for human populations but aquatic systems have been increasingly threatened, directly and indirectly, by human activities as well as stress of global climate change.The important part of global ecosystem are aquatic species and habitats which can be affected by landslides and other factors affecting water quality, increasing stream temperatures, changes in lake and stream temperatures, changes directly to aquatic species and habitats, effects of other watershed disturbances and climate change-related other cumulative effects. The projected implications in aquatic ecosystem have significant implications for many fish species due to increasing lake and stream temperatures affecting aspects such as "frequencies of disease, increased energy expenditures, altered growth, thermal barriers to both adult and juvenile migration, delayed spawning, reduced spawner survival, altered egg and juvenile development, changes in biological productivity and other rearing conditions, and altered species distribution" (60).

3.2 Projections of Future Climate Change

The climate change models and projections published in different period in terms of CO_2 concentration and temperature represents complex scenarios. Projections of future global warming of baseline period of 1970-1990 can displayed different model/observations with their analysis of temperature rise and projected variations. One of the first John Sawyers in 1973, observed world would warm 0.6ºC between 1969 and 2000 with 25% increases of atmospheric CO_2. The consequent projections reviewed between the period and observation of future temperatures due to global warming are presented below in the table 3.

Table 3. Climate Change Projection and Observation Since 1970 to 2016

Global Warming	Projections (1970-2016)	Climate sensitivity of doubling 2.4C	CO2 concentrations	Reference
0.6°C	+25%	0.51 °C and 0.56 °C	375-400ppm	John Sawyer, Nature in 1973 (61)
0.82 °C	+30%	Estimated CO_2-424ppm Observed CO_2-404ppm	370-373ppm	Prof Wally Broecker, in Science, 1975 (62)
0.85 °C	-20%	Climate sensitivity of 2.8°C per doubling CO_2 range of 1.4-5.6°C per doubling	20% lower than observations	Hansen et al, 1981, NASAs
1.16°C	+30%	0.82°C in 2016, Scenario A-1.16°C	Scenario B 401ppm in 2016	Hansen et al,1988 **(63)**
0.84°C	+17%	Climate sensitivity as 2.5°C warming for doubled CO_2, with a range of 1.5-4.5°C.	418ppm CO_2 in 2016, compared to 404ppm in observations, BAU scenario	IPCC's First Assessment Report (FAR) in 1990 **(64)**
0.85°C	-28%	climate sensitivity of 2.5°C, with a range of 1.5-4.5°C	CO_2 levels of 405ppm in 2016	IPCC's SAR 1995
0.82°C	-14%	Climate sensitivity of 2.8°C per doubling CO_2, with a range of 1.5-4.5°C	A2 scenario projected a 2016 atmospheric CO_2 concentration of 406 ppm	IPCCs TAR 2001
1.17°C	+8%	Models used in AR4 had a mean climate sensitivity of 3.26°C, with a range of 2.1°C to 4.4°C	Identical CO_2 concentrations 2016 of the A2 scenario	IPCC's Fourth Assessment Report (AR4) 2007
1.1°C	16%+	AR5 introduced Representative (RCPs)	Warming shows 9% faster than observations, 430 ppm-2011, 450ppm-2100	IPCC report – the Fifth Assessment (AR5), 2013

Sources:https://www.carbonbrief.org/analysis-how-well-have-climate-models-projected-global-warming

The fifth assessment report of IPCC has projected global mean surface temperature ranging 0.3°C to 0.7°C for the period 2016-2035 and largely increase carbon dioxide (CO_2), methane (CH4), and nitrous oxide (N_2O) GHG's in the atmospheric concentrations. The cumulative anthropogenic CO_2 in the atmosphere between 1750 and 2011were 2040 ± 310 $GtCO_2$. Among them, nearly 40%

(880 ± 35 $GtCO_2$) emissions have remained in the atmosphere, 30% observed by the Ocean and rest was stored on land. The projected global surface temperature at the end of 21st century (2081-2100) is to *likely* exceed 1.5°C for RCP4.5, RCP6.0 and RCP8.5 and change for warming is *likely* to exceed 2°C for RCP6.0 and RCP8.5 (*high confidence*). The CC synthesis report 2014 of IPCC summarize global mean surface temperature to be increase 0.3°C to 1.7°C by the end of the 21st century (2081-2100) relative to 1986-2005 under RCP2.6 and 1.1°C to 2.6°C under RCP4.5, 1.4°C to 3.1°C under RCP6.0, and 2.6°C to 4.8°C under RCP8.5.

Nepal is least country with 0.027% of total global GHGs emissions. The total GHGs emission recorded in 2008 was 30,011 CO_2-eq Gt, which found increased from l24 to 541 CO_2-eq Gt GHG emissions in 2000. Considering the country as a party of United Nations Framework Convention on Climate Change (UNFCCC), Nepal limits temperature below 2°C leading to 1.5°C above pre- industrial levels. The direct cost of current climate variability and extreme events form agriculture, hydropower and water-induced disasters has estimated 1.5 to 2% of current GDP/year (approximately USD 270-360 million/year in 2013 prices) as per the Economic Assessment study of climate change in 2013.

3.3 Climate Change Mitigation and Promotion of Renewble Energies

Conference of the Parties (COP) of UNFCC 2010 agreed to limit global warming below 2.0°C (3.6°F) relative to the pre-industrial (65) and the Paris Agreement 2015, parties revised to achieve warming below 1.5°C (66). To meet this agreement each country necessarily be committed to reduce the GHG emission and promote clean energy sustainably replacing the fossil fuel combustion. Nationally Appropriate Mitigation Actions by developing country Parties pursuant to decision 1/CP.16, paragraph 50, are compiled in document FCCC/SBI/2013/INF.12/Rev.2. Negotiations pursuant to the Bali Action Plan concluded at COP 18 in Doha. As a part of the agreed outcome, developing countrys Parties will take action for sustainable development.

Nationally Appropriate Mitigation Actions (NAMAs) supported and enabled the umbrella of a national governmental initiative to reduce emissions in developing countries. LULUCF activities in the mitigation of climate change increase the removals of greenhouse gases (GHGs) from the atmosphere or decrease emissions by sources leading to an accumulation of carbon stocks accumulated through growth of trees and an increase in soil carbon.

The world's forests and other wooded lands store more than 485 gigatonnes (1Gt=1 billion tonnes) of carbon, 260 Gt in the biomass (53 percent), 37 Gt in dead wood and litter (8 percent) and 189 Gt in soil (39 percent) as per the Global Forest Resources Assessment 2010 (FRA 2015). The deforestation, degradation and poor forest management can reduce carbon stocks wheras sustainable management, planting and rehabilitation of forests can conserve or increase forest carbon stocks. Due to the degradation and deforestation of global forest area, carbon stocks in forest biomass decreased by an estimated 0.22 Gt annually during the period 2011–2015.

For our sustainable future, curbing energy contribution and securing energy supply are challenging to the climate change (67) as 1.4 billion people of the world lacks access to electricity where 85% of them live in rural areas. Due to lack of electricity in rural areas, communities relying on the traditional use of biomass which is projected to rise from 2.7 billion today to 2.8 billion in 2030 (68). The large uses of fossil fuel based energy like Coal, Oil and Gas has extremely increased CO_2 emission globally together with rapid population growth (69) which is the major global challenge to reduce CO_2 emission and promote renewable energy. Promotion of renewable energy can displace greenhouse gas emissions from fossil fuel-based power generating and thereby mitigating climate change (70).

To mitigate climate change in sustainable manner, renewable energy can play important role to reduce GHG emissions. Promotion of green energy a Nationally Determined Contributions commitments presented to the COP21 and consideration of holistic approach to balance energy security and energy equity efforts for environmental sustainability, **World Energy Council, 2015** proposed World Energy Trilemma for priority actions on climate change and mitigation.

A green energy like sunlight, wind, rain, tides, plants, algae and geothermal heat, produced from natural sources have less impacts on the environment. Among the source of green energy generating worldwide like solar power, wind power, geothermal energy,and biofuels, hydropower is an important source of clean energy which can contribute to reduce the use of fossil fuels. According to IEA 2012a, Asia will contribute nearly half of global carbon dioxide (CO_2) emissions (71) and calls to limit global warming to 2^oC above preindustrial levels as target agreed under UNFCC.

3.4 Hydropower Development

Hydropower derived from the Greek word ύδωρ, "water" and power from the energy of fast running water which was first house powered by hydroelectricity in 1878, the late 19th century (72). Firstly, vertical and horizontal axis hydraulic machines was introduced by Bernard Forest de Bélidor, a French engineer in mid-1770s publishing article an Architecture Hydraulique however, hydraulics electrical generator was developed in USA in the late 19th century. The first hydroelectric power scheme was developed byWilliam George Armstrong in 1878 at Crag side in Northumberland, England (73). First commercial hydroelectric power plant, Niagara Falls was built in 1879 and the city of Niagara Falls was powered by hydropower in 1881. The Vulcan Street Plant 12.5 kilowatts capacity was the first hydroelectric power station, Edison operated from September 30, 1882, in Appleton, isconsin (74). Growing progress in hydropower worldwide, 45 stations were built within US and Canada by 1886 and reached 200 numbers in US only by 1889 (75).

The total hydropower capacity is 936GW across 11,000 hydropower stations in the world at the end of 2011. Among the 160 countries with hydropower capacity, China, Canada, Brazil and the USA are leading countries (WEC, 2016) (76). The largest renewable energy a hydropower shares 16% of worlds electricity demand 25 country depending on hydropower and 90% electricity supply (99.3 % in Norway), and 12 countries are 100 % reliant on hydro. Worldwide 65 countries produces bulk of electricity, plays role in more than 150 countries. The countries having largest hydropower generation capacity are Canada, China and the United States (77), (78), (79) and (80). The most flexible source of energy hydropower delivered base load power, storing electricity over weeks, months, seasons or even years (81) and (82). According to UNDP 2012 (83), around 1.4 billion people of the world have lacks access to electricity and intermittent access to 1 billion only. Based on the demand and catchment condition of the river hydropower can be small scale or large-scale, depending on the local conditions and the energy demand. Hydropower can be classified large scale more than 100MW, medium scale 10-100MW, small 1-10 MW, Mini Small scale 100 kW to 1 MW, Micro 5-100kW and Pico <5kW capacity (84). The large-scale hydropower plants are classified as conventional hydroelectric dams, pumped storage, run-of-the-river and tidal (85). Hydropower can contribute up to 16,400 TWh/yr and installed hydropower capacity will double (1,947 GW) by 2050, generating an annual 7,100 TWh (86).

Hydropower Baseline and Electricity Generation

China is the largest country for hydropower production (920 TWh in 2013) among the 150 hydropower producing country and Asia-Pacific region represents 33% production of hydropower globally in 2013. Hydropower provided 16% worlds electric energy whereas fossil fuel secondly provided 950 GW worlds energy comprising China 24%, USA 8% and 9% Brazil in 2011 (87) (Fig.4). The estimated cost of electricity larger than 10MW hydro station is 3 to 5 U.S. cents per kilowatt in an average (88) and after construction it has lower output level of greenhouse gases than fossil fuel powered energy plants (89).

The energy growth of the world depends on increasing demand of the energy as the non-OECD increase by 71% between 2012 and 2040 in compared to the OECD nations with an increase ratio of 18%. The worldwide consumption of hydro, geothermal and biomass electricity in 2015 was equivalent to 1010 million tons of oil around 8%of world's energy consumption.

The projected primary energy demand of Asia and the Pacific is increasing at the ration of 2.1% per year from the period of 2010 to 2035. It is faster than the globally projected growth rate of 1.5%/year in an average during the same period. Considering this growth rate, energy demand of Asia and the Pacific will reach from 4,985.2 Mtoe in 2010 to 8,358.3 million tons of oil equivalents (Mtoe) by 2035.The estimated renewable power capacity including hydropower comprised more than 25% by the end of 2011, which was estimated at 5,360GW in 2011 and supplied around 20.3% of global electricity (90), (91). Among the main renewable energy investor of the Asian countries, China, India, and Japan are the top among the seven countries in 2011(92), (91).

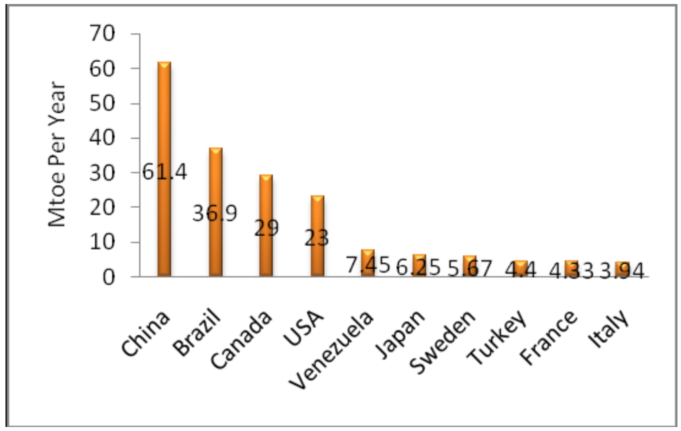

Figure 2. Top Hydropower Producing Countries (Mtoe per year), WEC, 2016

Hydropower and wind are the two largest contributors to the increase in world electricity generation increased by about 1.9 trillion kilowatt-hours (kWh) (92). The increases growth of hydropower generation from mid to large-scale power plants in the non-OECD region provides nearly 40%. However, in OECD countries consumption of renewable energy from non-hydropower sources attributed to 82% (92).

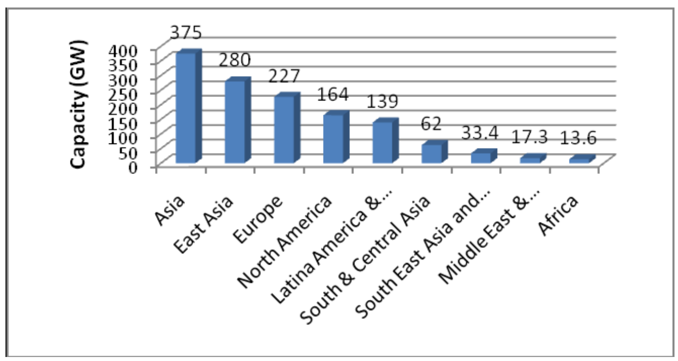

Figure 3. Hydropower Installed Capacity by the Region

The electricity generation in Asia and the Pacific was 6% from 1990 to 2010 which to be grow 3.2% annually as projected reaching 18531 tera watt/hours (TWH) in 2035. The projected electricity demand in Asia and the Pacific, 7,010.4 TWh in 2010 will be increased more than double annual growth rate of 3.4% 16,169.2 TWh in 2035. Among the renewable source of energy in Asia, hydropower has significant potential with installed 542GW capacity and 2,204 GW potential (Fig. 3). It has developed only 20% hydro resources (93) and developed 337 GW in 2010 approaching total 1700GW hydro potential (94).

The growing energy demand has estimated 11,500 MW by 2030 for moderate GDP growth (5.6 %) and higher demand for GDP growth of > 8 percentage. Thus, the existing policy and legal arrangement needs to be put in a place, considering the present situation for the sustainable development of hydropower for the overall development of the country. As per the WECS energy strategy 2012, Clean Energy Technology (CET) scenario, the fossil fuels should be decreased by 20% by 2020 and 30% by 2030.

3.5 Promotion of Green Energy Hydropower : A Case Study of Nepal

Hydropower development a source of cost-effective and low-carbon renewable energy adopted about 160 countries (95) with capacity of 1209 GWe generates about 3 500TWh per year which is equivalent of 15.8% electricity generation globally estimated in 2011 (96) and 35 countries providing 50% electricity out of the total supply (97).

Among them, Nepal has big hydropower potential to generate electricity as using main source of energy with it's nearly 90% installed and generation capacity of electricity. Previous studies have estimated 83,000 MW hydropower potential which is now conformed 45,610 MW as commercially feasible. Similarly, other renewable energy resources commercially exploitable, Nepal resemble 100 MW of micro hydropower; 2,100 MW of solar power for the grid; and 3,000 MW of wind power. Nepal has projected 10000MW electricity production within 10 years and 17000MW by 2030. Currently, 63 projects of 907.509MW above 1 MW installed capacity and 13 projects of 9.975MW below 1MW inctalled capacity till date November 2017 are in operation. The maximum peak load as noted at 18 hour is about 2,122,874.85MWh in 2015/16 and 2,287,876.78MWh in 2017 (1094.62 MW) showed current net deficit of around 340 MW. The details of hydropower development and status is presnted in the table 4 (98).

Table 4: Status of Hydropower Development in Nepal

Particulars	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Production (MW)	697.85	705.57	746	746	**782.45**	**812**	**846**
Transmission Line (Km)	1917.62	1987.36	1987.36	1987.36	1987.36	2640	2848
Customer Growth	1864067	2056292	2599156	2713804	2833043	2969376	3257812
Distribution Line (Km)	89108.9	95816	114160	116067	116091		
Available Energy (GWH)	3858.37	4168.63	4268.08	4687.09	5005.2	5077.14	6257.73
High Demand (MW)	946.1	1026	1094	1200.98	1291.1	1385.3	1444.1
Demand Supply Gap (MW)	248	-320.43	348	-454.98	508.65	550	340

Current electricity generation power plants and project showed 11 major hydropower stations are in operation of 459,150kW (459.15MW) installed capacity and 473,394kW (473.394MW) capacity of small hydropower plants including 53,410kW- 53.41MW production from thermal power plants. Out of total 972.492MW installed capacity energy of Nepal in 2017 Hydropower producing 918.982MW, 53.41MW from Thermal plants and 0.1MW from solar energy including 1047.1MW installed capacity are in uder construction and 2770.2MW planned and proposed. Existing high voltage transmission lines & substations length circuit km is 3,465.76.

3.6 Contribution to Reduce CO_2 Emmision

As hydropower produce small amount of GHG, time series of emission trends of COBenjamin K. Sovacool 2008. This value is only 1.67% of GHG emmission incomarision to energy produced from disel and oil which produced 98.33% emmision of CO_2 from hydropower in Nepal from 2010 to 2017 is shown in the table 5. In 2010 the total installed generation of 697.85MW electricity from hydropower has estimated emmision of 30.24 g co2/kWhe and around 860MW production of hydroelectricity estimated 37.27 g CO_2/kWhe in 2017 as per the measurement estimated valuing of greenhouse gas emmission adopted by $_2$ than the hydropower (Table 5)

Table 5: Lifecycle greenhouse gas emission estimates of Hydropower vs Disel/Oil based on Benjamin K. Sovacool's comparison (99)

Year	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	Total	%
Production(MW)-Hydropower	697.85	705.57	746	746	782.45	846	860	5383.87	100
Estimate (g CO_2/ kWhe) Hydropower	30.24	30.57	32.33	32.33	33.91	36.66	37.27	233.30	1.67
Estimate (g CO_2/ kWhe) Disel/ Oil	1809.76	1829.78	1934.63	1934.63	2029.15	2193.96	2230.27	13962.17	98.33
Reduction of GHG by Hydropower (g CO_2/kWhe)	1779.52	1799.20	1902.30	1902.30	1995.25	2157.30	2193.00	13728.87	98.33

Based on the mean value calculated for the overall emissions by averaging the global results of 19 LCA [Life-Cycle Analysis] studies adopted by Sovacool (2008), GHG production from RoR types of hydropower production from 2010 to 2017 has been estimated, comparing to the estimated CO_2 emmission from the fossil fuesl(Disel/Oil). The result showed that the hydropower development has reduced 98.33% g co2/kWhe CO_2 emmssion in the atmoshpere (Fig.4).

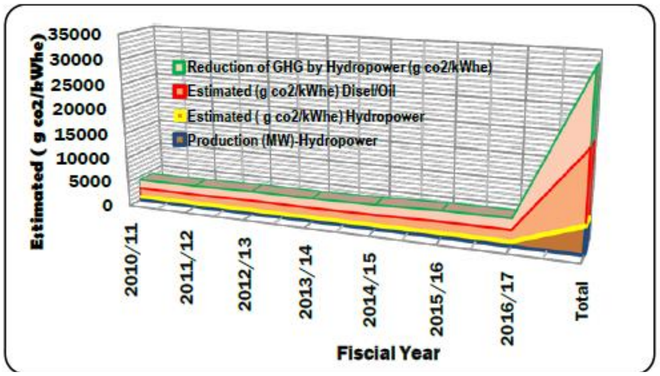

Figure 4. Hydropower Development and GHG Emmsison from 2010 to 2017 in Nepal

Nepal's concern towards conservation and sustainable economic development has signatory of more than 20 international treaty and conventions like Biological Diversity (CBD) and UN Framework Convention on Climate Change (UNFCCC) in 1992, UN Convention on Combating Desertification (UNCCD), 1994 and Kyoto Protocol in 1997.The climate change issues raised in Nepal formed Climate Change Council in 1999 and adopted Climate Change Policy in 2011 with its main aim to improve socio-economic development with improvement of livelihoods by mitigating and adapting adverse impacts and adoption of low-carbon emission based development.

Nepal's Climate Change Policy (2011) has envisaged protection of environment and sustainable human development by promoting the use of clean energy, reducing GHG emissions, enhancing the climate adaptation and resilience capacity of local communities. The emissions of carbon threats basic elements of society like water, food production, health and the environment imposing a huge social cost as anywhere from $8 per ton to as high as $100 per ton of CO2. The main source of CO2 generation, more than 50% of the emissions from fossil fuel combustion for transportation and electricity generation and 66% from thermal power plants, which is the world's electric generation capacity. However, the hydropower represents only 20% electricity generation capacity of the world which emits 35 to 70 times less GHGs per TWh than thermal power plants (IAEA 1996) (100). To achieve energy efficiency and energy security, the hydropower projects aim to access affordable and reliable energy service and reduce high carbon emission replacing petroleum products to the extent possible in transport, industry, and household sectors.

4. Conclusion

The emerging issues climate changing earths temperature bringing global warming with numerous effects on the world's natural ecosystems and their functions. Several studies have observed a warming trend beginning around the late 1800s with thermal expansion, melting glaciers and ice caps, and the polar ice sheets resulted sea level rise in average rate of 1.8 [1.3 to 2.3] mm/yr since 1961 and since 1993 at 3.1 [2.4 to 3.8] mm/yr. The global temperature showed about 1.3°F average warming over the past century and it will increase more than 3 to 7°F by 2100. An increase of baseline global GHG emissions projected by SRES scenarios with a range of 9.7 to 36.7 GtCO2-eq (25 to 90%) between 2000 and 2030. The projected dominant position in the global energy mix to 2030 and beyond CO2 emissions from energy use between 2000 and 2030 will grow 40 to 110% over that period. Recent prediction of global warming showed an average global temperature could increase between 1.4 and 5.8 °C by the year 2100.

Climate change impacts of renewable resources shares driving adaptation including glacial run-off and variability of rainfall through operational changes, modifications to existing plants, and changes to the design of new hydropower plants[29, (101)]. The major parameters of climate changes in the river basin with relevance to hydropower generation are changes in precipitation patterns and temperature with volume, timing, intensity, relative proportion of rainfall and snowfall affecting in the river flow in terms of timing, magnitude, and duration, droughts frequency and floods, evaporative rate, water loss, glaciers melting and groundwater influx for base flows. The changes in the seasonal distribution of precipitation, year-to year variability affects frequency of low or drought flows with occurrence of prolonged droughts (102). The assessment of climate change in water resources included in IPCC reports (103), climate change and water a technical paper (Bates et al. 2008) describing the climate change in the river basins and studies on climatic variability within key hydrological processes (104), (105), (106), (107), (108), (109).

About 15 000 TWh (1) estimated technical potential of hydropower globally (110) can assumed to mitigate climate change replacing fossil fuel (111) (112) generation low emmission 28 gCO2e/kWh than other energy sources with mean values ranging from 490 g CO2e/kWh for gas-firedgeneration up to 820 g CO2e/kWh for coal-fired generation (112). Climate change impacts can be addressed through promotion of other clean energy sources however such sources has associated impacts for example hydropower occurs first order abiotic and biotic impacts influencing downstream river and connected ecosystems (changes in flow, water quality and sediment load) including modification of primary productivity in long terms. Similarily biotic impacts and changes resulting from the integrated effect of all the first and second order changes, including the impact on species close to the top of the food chain changes in invertebrate communities and fish, birds and mammals (113).

Hydropower projects accquare lands and removal of associate forest area impacts on local ecosystem fragmenting the vegetation and wildlige species (114) resulting long-term interactions between the vegetation and site factors over time and space (115). The multipurpose dependency of local communities on the river, impoundments after damming the rivers adversely affects fish biodiversity, economics of fishing communities and livelihood of local people (116). The Himalayan region inhabitant of 1.3 billion peoples main source are the nine largest rivers in Asia which largely influencing by warming in Nepal and Tibet increased progressively within a range of 0.2-0.6 degrees Celsius per decade between 1951 and 2001 (115).

Nepal's technical potential in 45610 MW of hydropower, major river accounts 72450 MW and small rivers have 10840 MW theoretical potential of hydroelectricity of river catchments areas above 1000 km^2 and 300-1000 km^2 respectively. Fiscal year 2014/15 showed only 2.49% consumption of energy used from solar, biogas, micro hydro and wind energy whereas 19.88% consumption from coal, petroleum and electricity, rest 77. 63% from fuel wood or traditional sources (117). Nepal is most vulnerable to climate change, water-induced disasters and hydro-meteorological extreme events such as droughts, storms, floods, inundation, landslides, debris flow, soil erosion and avalanches. NAPA 2010 suggested highly vulnerable districts in terms of landslide prone areas 22, GLOF 12 and 9 for flooding (118). National communication report 2015, has described burning fossil fuels such as natural gas, coal, oil and gasoline raises the level of carbon dioxide in the atmosphere, and carbon dioxide is a major contributor to the greenhouse effect and global warming.

These vulnerabilities are being exacerbated by climate change. As detailed in Nepal's Second National Communication to the UNFCCC, 2015 (119), Nepal's hydropower plants are highly vulnerable to the projected impacts of climate change as they depend upon river basins fed by glacial melt water and snowmelt. The challenging environment in Nepal, faster receding of Himalayan glaciers than the other glaciers in the world (120). The total 3252 glaciers in Nepal covering a total area of 5312 sq km studied in 2001 whereas 3808 glaciers covering an area of 4212 sq km reported in the study of 2010 (121). Most climate models predict significant changes in the dynamics of Mountain glaciers, snowmelt and precipitation as the climate warms. The International Commission on Large Dams (ICOLD) (122) has already emphasized the urgent need to adapt older dams to cope with the impacts of climate change. At the same time, Nepal's Poverty Reduction Strategy emphasizes the importance of increasing the availability of affordable energy and using Nepal's abundant hydropower resources to promote economic growth and development.

Internationally Determined Contributions (INDC) 2016 (123), acknowledges the high vulnerability of Nepal's energy sector to climate change, and identifies this as a crucial dimension of the country's overall vulnerability to climate change, and as a critical threat to the economic well-being, livelihoods and energy security of the Nepalese population. Nepal's hydropower plants and indeed its entire energy system are already vulnerable to extreme weather events, as made clear by the NEA/WECES Energy Status Reports. However, for implementation of INDC, Nepal will contribute global efforts to reduce GHGs emissions for life-support systems adapting and build climate resilience development to mitigate climate change impacts. The renewable energy demand needs to be integrated in other sectoral policies (124).

The annual generation from hydropower plants in Nepal is 3,635 Gigawatt hours (GWh) or 73% of the total supply. The remaining 27%, or 1,370 GWh, is imported from India. Nepal's domestic hydropower supply includes 1,269 GWh (35%) which is sourced from Independent Power Producers (IPPs), while 2,366 GWh (65%) is supplied by Nepal Electricity Authority's (NEA) power stations. From the existing 800 MW of installed capacity, domestic demand is expected to grow to more than 6,000 MWs by 2030.Safe and sustainable energy for all is one of the key goals of the **2030 Agenda for Sustainable Development.**

UNFCCs ratification of global climate change by 148 countries in June 2017 after years of negotiations, 195 countries in December 2015, Paris climate change agreement comes into effect to limit global temperature rise to two degrees Celsius above pre-industrial levels by 2100. Considering to Paris agreement to reduce 40-70% GHG emissions by 2050 and carbon-neutral by 2100, all country must promote clean energy together with green ecosystem to replace huge use of fossil fuels.

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