Chapter

Consequences of Climate Change Impacts and Implications on Ecosystem and Biodiversity; Impacts of Developmental Projects and Mitigation Strategy in Nepal

Ramesh Prasad Bhatt

Abstract

Climate change impacts and implications towards ecosystems and biodiversity, water resources, food production, and infrastructures can be mitigated through adapting, reducing or avoiding adverse impacts and maximizing positive consequences. It can have numerous effects on the world's natural ecosystems and their functions. IPCC projections showed approximately 10% of species to be at an increasing high risk of extinction for every 1 °C rise in global mean temperature and recommended to limit global temperatures below 1.5 °C. To identify consequences of climate change, impacts, and implications, data collected from different sources, reviewed, assessed and analyzed, discussing dimensional impacts and mitigation strategies adopted. Nepal's 118 major ecosystems and 75 vegetation types with 44.74% forestland comprising 0.1% of global landmass harboring 3.2% flora and 1.1% fauna of the world's biodiversity critically influenced by the regional climate change and intervention of developmental projects. Since 2000, Nepal lost forest area by 2.1% including several endangered and threatened species. Nepal is highly vulnerable towards natural disasters like GLOF, Glacier retreat, flooding, landslide and global warming. Therefore, it is crucial to plan climate resilience infrastructures adopting effective environmental management tools, formulation of strong plan, policy and strategy, mitigation of greenhouse gases, climate resilient adaptation and restoration of degraded ecosystems.

Keywords: climate change, ecosystem and biodiversity, development projects, impacts and implications

1. Introduction

The overwhelming global effects of climate change and its implications subtle changes in the earth's orbit belongs long term and immediate impacts. The impacts on atmosphere, ecosystem and sea as a consequences of human activities, warming globe, raising air and sea temperature dropping by 0.01 °C every 100 years for the last 7,000 years and since 1970 the temperature has been rising at an alarming rate of 1.7 °C per century. Consequently, IPCC efforts recommended limit global temperatures below 1.5 °C to avoid the more severe impacts of global warming [1].

The warmer temperature due to climate change increases frequency of ground level ozone, lethal air pollutants, and smog components [2]. Both the immediate impacts of climate change regards extreme weather, heat waves, storms, and flooding, forest fire, compromised safety, economic challenges and long-term effects likewise on human health, ecosystem, threats on water and food resources, altitudinal and tree line shifting are the consequences of climatic change issues today. The pragmatic climate change effects sensed on environment globally comprises shrinking glaciers, shifted plants and animals ranges and sooner tree flowering, loss of sea ice, enhanced sea level rise, penetrating heat waves affecting our dependency upon water, energy, terrestrial and aquatic ecosystems, agriculture, and human health. The future prediction of climate change has great challenge to preserve existing ecosystem and biodiversity. The projections showed 10% approximate species to be an increasingly high risk of extinction for every 1 °C rise in global mean temperature, within the range of future scenarios modelled in impacts assessments (typically <5 °C global temperature rise) as per IPCC AR4. The vulnerable ecosystems are freshwater habitat and wetlands, arctic and alpine ecosystems, cloud forests, mangroves, coral reefs to the impacts of climate change.

The impacts of climate change has extremely affected human societies and the natural environment. The most vulnerable to climate change impacts on an ecosystems area associated with the shifting alpine ecosystem to higher elevations and shrink in area, modification on tropical and subtropical rainforests, affected coastal wetlands by sea-level rise and saline intrusion, affected inland ecosystems by changed rainfall patterns and affected tropical savannahs by changes in the frequency and severity of bushfires. According to Dolling et al. [3]; Giambelluca et al. [4]; Frazier et al. [5]; increased drought stress of native plants and fire occurrence is due to decreasing rainfall and increasing temperatures. According to the IPCC 5th Assessment (IPCC 2013) [6], ocean surface temperature and combined land and warming globally was around 0.85 [0.65 to 1.06] °C, over the period 1880 to 2012. The issue of climate change have created by human activities is about 1 °C of global warming above pre-industrial levels with range of 0.8° to 1.2 °C [7]. The large influence on forest and agricultural systems due to increases in temperature, changes in precipitation patterns, and changes in the occurrence of floods and droughts has predicted by the Álvaro-Fuentes et al. [8]; Anaya-Romero et al. [9]; Conant et al. [10]; Lal [11]; Muñoz-Rojas et al. [12].

As an important environmental factor, climate influence ecosystems and biodiversity several ways whereas climate change affects habitats of species and existing food chain interacting other human stressors like development. The stressors cause minor and major affects including dramatic ecological changes some of their cumulative impacts [13]. Due to changes in the timing of seasonal life cycle, many species influences their migration, blooming and reproduction including reduced their growth and survival [14, 15]. The habitat range of the species both terrestrial and aquatic environment shift to higher elevations due to increased temperatures including changes in vegetative biomes [16] and expanding into areas of river and streams previously inhabited by Coldwater species [17]. Similarly, particular species can ripple through a food web and affect a wide range of other organisms as the loss of sea ice affected entire food web, from algae and plankton to fish to mammals [18]. The extreme events like wildfires, flooding, and drought serves ecosystems as natural buffers and human modification restrict ecosystems' aptitude to temper the impacts of extreme conditions which increases vulnerability to damage. Likewise, the main stressors of climate change like habitat destruction and pollution subsidize to species extinction and spread of pathogens, parasites, and diseases, with potentially serious effects on human health, agriculture, and fisheries. Thus, the species extinction rate globally is exceeding the observed natural rate of extinction [19].

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In Nepal, the major driving force to degrade biodiversity and ecosystem is development of infrastructures such as construction of road, hydropower, irrigation canal, railway, transmission line, tourism industry and airport. The accelerated impacts of these activities allies with deforestation and degradation of natural forests, habitat fragmentation, infrastructure development on protected areas, encroachment of forest and forest land, destruction of natural habitats both terrestrial and aquatic species. The urbanization and population growth leads to unplanned infrastructure development ultimately has increased demand of natural products, and pressure on biological resources threatening natural ecosystem and biodiversity.

The rainfall patterns and temperature regimes altered by the climate change and its impacts on water, agriculture and biological resources are crucial issues in Nepal. The policy of the government in biodiversity conservation and economic development is ineffective for implementation integrating the development actions. An effective implementation of regulatory framework and strategy to protect biological resources including protected, endangered, threatened, rare and endemic species can support to conserve the biodiversity and ecosystem. Thus, the chapter assisted overall climate change scenario describing impacts and implications, focusing on ecosystem and biodiversity, including impacts of developmental projects, adoption of national mitigation strategy and use of assessment tools with Nepal's perspective.

2. Material and methods

2.1 Study area

A landlocked country Nepal situated between 80°and 88° E longitude and from 26° to 31° N latitude which covers an area of 147,181 Sq.km measuring 880 kilometers (547 mi) along its Himalayan axis by 150 to 250 kilometers (93 to 155 mi) across. The new

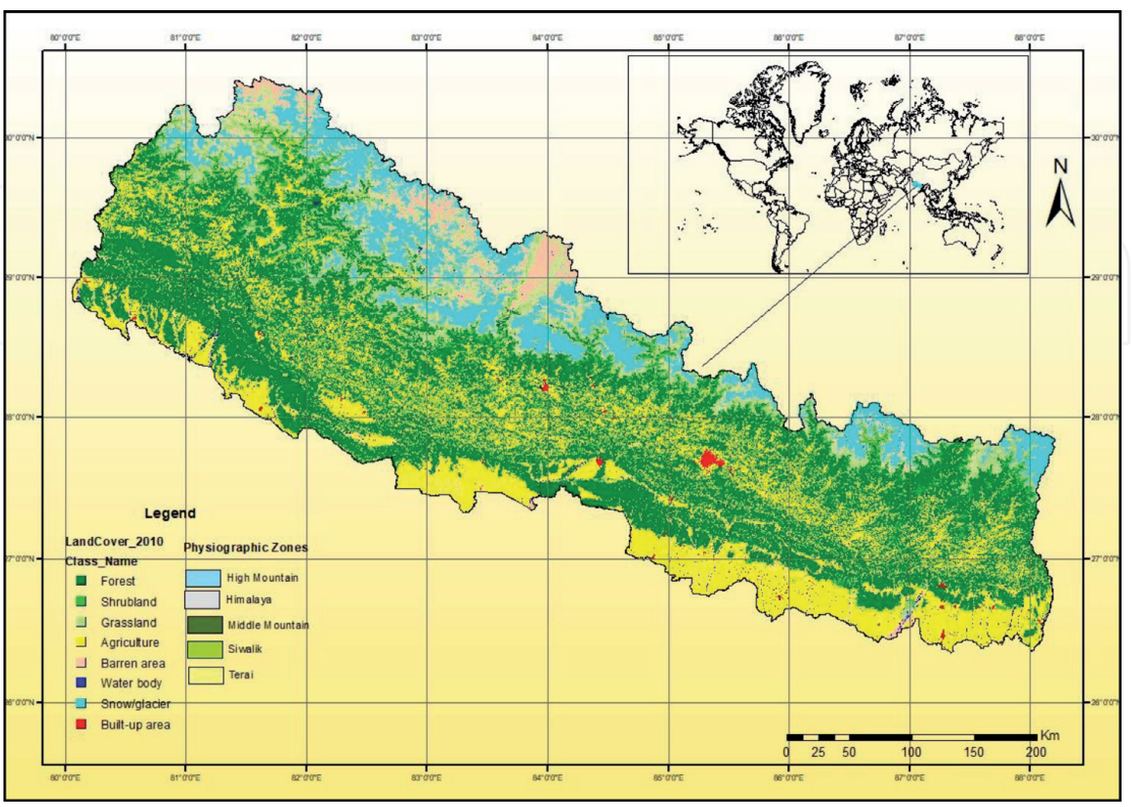

Figure 1.
Landuse pattern of Nepal.

map showing Kalapani, Limpiyadhura and Lipulekh as Nepali territories, Government of Nepal has further declared as an extended area of 147, 516km^2 (56,956 sq. mi) [20]. Nepal resembles five physiographic zones and seven bio-climatic zones identified by Dobremez [21] extending from East to West, including the High Himal, High Mountains, Middle Mountains (or Middle Hills), Siwalik (or Chure), and Terai [22] (**Figure 1**). The genetic, species and ecosystem level biodiversity of Nepal spreads over tropical forests from Terai (67-1000 masl), mid hill (1000-2000 masl) subtropical and temperate regions (2000–3000 masl) to Himalayas sub-alpine and alpine pastures and snow-covered peaks of the Himalayas (> 3000 masl). As shown in **Figure 1**, land cover in Nepal includes different types of forests (broadleaf, needle leaf, mixed), agriculture, shrub lands, grasslands, bare lands, river and lakes, and glacier/snow [23, 24].

3. Methods

Relevant literatures reviewed, summarized current estimates of the impacts of climate change as per IPCC and The World Bank data, and explained how those estimates assembled in order to identify the main sources of uncertainty and approximately affecting them. In addition, discussed scenarios of development actions and impacts, uncertainty influences and mitigation measures adopted through legal instruments and policymaker's decisions. The reviewed national and international policies, plan, strategies, Act and regulations were incorporated with the relevancy and implications in ecosystem and biodiversity and other thematic areas. AcrGIS_10.4.1 was used to delineate land use pattern and forest cover together with identification of Physio geographic zones of Nepal with reference of GoN/MoFSC, 2018 [25] and national scale forest resource assessment carried out over the period of 2010–2014 [26]. In the decision making process, EIA legislation and its process subjected to an environmental assessment during preparation, and before adoption. Similarly, integration of EbA approach into policies and plans for facilitating EbA technology, synthesis and packaging of information and planning tools was carried out to found alternative scenario for climate change adaption with resilience ecosystem. Impacts and implication of developmental projects, legal provisions to conduct environmental assessments and mitigation strategy were identified through review pertinent documents and study of infrastructure projects such as hydropower, roads and other sectoral projects.

4. Impacts and implications

4.1 Ecosystem and biodiversity

The increasing impacts of climate change on biodiversity become a progressively more significant threat in the coming decades as projected. The pressure of ocean acidification, resulting from higher concentrations atmospheric CO_2 and loss of Arctic sea ice threatens biodiversity across an entire biome and beyond. The frequent extreme weather events with changing pattern of rainfall and drought, warming temperatures as projected there are significant impacts on biodiversity and ecosystem [27]. According to IPBES the three major challenges like land degradation, biodiversity loss and climate change increasingly dangerous impact on the health of our natural environment degrading land, pollution and overexploitation to land-use change and habitat loss threat to wildlife globally. As per the IPCC [28] AR4 projection 10% of species assessed approximately are in high risk of extinction for every 1 °C rise in global mean temperature, within the range of future

scenarios modelled in impacts assessments (typically <5 °C global temperature rise). In particular, aquatic freshwater habitats and wetlands, mangroves, coral reefs, arctic and alpine ecosystems, and cloud forests are vulnerable to the impacts of climate change.

Nepal is rich for globally significant biodiversity with 118 major ecosystems and 75 vegetation types harboring important flora and fauna occupying 39.6% (5,830,360 ha) forest area. Currently, out of total area of the country, 44.74% (6.61 million ha) is covered by the forests land including 17.32% Protected Areas (PAs) and 82.68% by other forest management regimes [29]. Nepal has established 20 protected areas with the goal of nature conservation covering 23.39% (34419.75 sq.km.) land area with2 12 National Parks, 1 Wildlife Reserve, 1 Hunting Reserve, 6 Conservation Areas, and 13 Buffer Zones extending from lowlands of Terai to high mountains.

Globally, Nepal occupies about 0.1% of global landmass harboring 3.2% flora and 1.1% fauna of the world's biodiversity including 5.2% of mammals, 9.5% birds, 5.1% gymnosperms and 8.2% bryophytes [30]. Similarly, Nepal government has declared 27 mammals, nine birds, 3 reptiles [31] under protection category. Among 208 mammal species recorded in Nepal, regionally 8 of them critically Endangered, 26 Endangered, 14 Vulnerable and 7 species nearly Threatened. Out of 886 bird species found in Nepal, 42 of them are globally threatened [32]. The species of flora and flora of Nepal listed in CITIES includes, 50 mammals, 108 birds, 29 Reptiles, 2 amphibians and 476 species of plants [33]. The updated checklist of CITES flora after CoP 17 includes, 154 species with 1 species in Appendix I, 149 species in Appendix II and 4 species in Appendix III [34].

The use of resources like grazing, fodder and fuelwood collection, timber extraction, collection of herbs, medicinal and aromatic plants, poaching, hunting and fishing are major threats for conserve biodiversity conservation. Among the 700 species medicinal plants in Nepal, more than hundred species exploited for commercial purposes. Loss and fragmentation of natural terrestrial and aquatic habitats and restricted mobility of migrant species due to habitat fragmentation is crucial problem. Poaching of rare species such as the tiger, rhino, bear (*Selenarctos thibatenus),* musk deer, snow leopard, gharial, and others is also critical problems. Nepal were to lose its remaining humid tropical forests, 10 species of highly valuable timber, six species of fiber, six species of edible fruit trees, four species of traditional medicinal herbs, and some 50 species of litde known trees and shrubs would be lost forever. Likewise, severely affected wildlife habitats are 200 species of birds, 40 species of mammals, and 20 species reptiles and amphibians [35].

The loss of biodiversity and vegetation leads to the changing pattern of natural environmental conditions occurring from numerous fundamental systems and decreasing number of species biodiversity due to modified environment and increased pressure on forest and vegetation [36]. The major impacts on biodiversity and ecosystems are loss of habitat due to encroachment of forest areas, expansion of agriculture and settlement in forest area, development of infrastructure within the forest area, planned priority projects within forestland to uplift economic development. Other major problem also leads to degradation of habitat due to overharvesting of biological resources, overgrazing and uncontrolled forest fire. Similarly, poaching and illegal wildlife trade, human-wildlife conflict, invasion by alien plant species, stone, gravel and sand mining threats ecosystem and biodiversity of the country. Nepal lost forest area by 2.1 percent and 1.4 percent during 1990–2000 and 2000–2005, respectively [37]. Nepal's forest area heavily degraded with loss of important biodiversity imposing landslides, and soil erosion, felling of trees for building materials and over lopping for fodder and fuel wood [38]. The unplanned infrastructure development such as schools, hospitals, temples, water storage

tanks and other infrastructure within the forest area, particularly in the Tarai and Siwalik, 82,934 hectares forestland was reported under illegal occupation [39].

The major identified climate change impacts on forest and biodiversity in Nepal resembles; (a) increased temperature and rainfall variability, (b) changes in phenological cycles of tree species and shifting of tree line in the Himalaya, (c) shifts in agro-ecological zones, prolonged dry spells, and higher incidences of pests and diseases, (d) increased emergence and quickened spread of invasive alien plant species, (e) increased incidence of forest fire in recent years, (f) depletion of wetlands [40, 41]. The large scale development is a hallmark of the modern world, providing society with things humans' value but at an environmental cost [42, 43]. The major impacts on terrestrial or aquatic ecosystem associated with the developmental projects are:

- habitat degradation through overgrazing practices wetland drainage for agricultural, industrial or urban development practices;
- habitat loss, with attendant consequences on fish and wildlife because of excessive deforestation practices;
- changes in habitat and associated fish and wildlife species due to the construction and operation of hydropower projects;
- loss of critical habitat for endangered or threatened species as result or timber harvesting, recreational developments, and or military training activities;
- multiple aquatic and terrestrial ecosystem effects from acid rain formed as a consequence of SO_2 emissions from coal-fired power plants; and
- potential toxic effects to plants and or animals as a result of air-or water pollutant discharges or of waste disposal activities of industries and municipalities.

4.2 Infrastructures and development

The major infrastructures like road, hydropower, irrigation, water supply, housing, tourism and communication are associated with socioeconomic development of the developing country. Monsoon floods, landslides, and siltation-damaged infrastructures impede the developmental activities and affects transportation facility, electricity supply, industry, business, markets, and other allied activities. Furthermore, more extreme events associated with climate change forebodes great threat on infrastructures with increased instances of drainage congestion, scouring, inundation, slope instability, land subsidence, erosion, and collapse of structures. The existing roads, bridges, water supply and sanitation, settlement, hydropower and irrigation are affecting seasonally due to flooding, landslides, and debris deposits cause large impacts on socioeconomic development of the country. The degradation of key natural resources land, water, and forests and impacts on agriculture and livestock farming, agricultural production, transportation, infrastructure, forest-based industries, and hydropower, are associated with intensifies disasters such as landslides, floods, soil erosion drought and storms.

4.3 Hydropower development

Nepal is rich for water resources comprising 6,000 rivers with 220 billion cum annually run off spreading length of over 45,000 km. [44]. An estimated potential

for hydropower to be around 83,000 MW whereas 4300 MW to be technically feasible [45]. The major river basins in Nepal are Sapta Koshi, Karnali, Sapta Gandaki, Mahakali, and the Southern rivers [46]. In Nepal, with total installed capacity of 1,332,858 KW, 14 major hydropower stations, 17 small hydropower plants, 23 Small Hydropower Plant (isolated), Two Thermal Plants and Solar plants are currently in operation generating 56315KW, 577394KW, 4536KW, 53410 KW, and 1350KW energy respectively. Similarly, eight Hydroelectricity Project (HEP) with installed capacity of 943100KW are under construction and nine with installed capacity of 3219200KW are planned and proposed. Hydropower construction is growing development in Nepal due to rapid increment demand of electricity by about 10% every year (NEA) and projected demand for year 2020/2021 to be around 2,203 MW [47]. The hydropower development considerably cause high impacts on construction phase rather than its operation along with cumulative and long-term impacts can harass to sustain ecosystem and biodiversity. As location of the project, size and type of the project, socioeconomic condition the environmental situation, beneficial and harmful impacts of hydropower are considered manifold [48, 49].

Nepal in progress of installation of renewable source of energy such as mini and micro hydropower, solar energy, biomass energy and biogas targeting access public to provide clean, reliable and affordable renewable energy solutions by 2030. As different Nations agreed in Paris in 2015, limit the global average temperature rise to as close as possible to a maximum 2 °C reducing energy-related CO_2 emissions by more than 70% by 2050 which can only be achieved with the massive deployment of renewable forms of energy such as wind, solar and hydro, combined with energy efficiency [50]. NEA is responsible to generate electricity, transmission, and distribution but inadequate planning, policy, regulation and inadequate capacity with poor governance leading to underinvestment and difficulty in sustaining the growth of the Hydropower and Economic Growth in Nepal [51].

To institutionalize hydropower sector, Government of Nepal endorsed Water Resources Act, 1992, Water Resources Regulation, 1993, Electricity Act, 1992, Electricity Regulation, 1993 and Hydropower Development Policy, 1992, Hydropower Development Policy, 2001, Water Resources Strategy, 2002 and National Water Plan, 2005. GoN has also prioritized development of hydropower including contemplation of Environment Protection Act, 2019 and Environment Protection Rules, 2020. The perennial nature of Nepalese rivers and the steep gradient flows from Himalayas and high mountains towards the plain of the Terai has largest hydropower potential for hydroelectric projects in Nepal whereas challenges remaining to protection towards ongoing potential impacts on natural environment. Although, hydropower plants provide cost efficient and environment friendly power supply to improve energy services a displacing imported fossil fuels but most of the hydropower constructing in Mountains, Mid hills and Siwalik regions of the country are great threats to biodiversity and ecosystems of the region. Landslide dam outburst floods (LDOFs) is one of the major challenges for hydropower development in Nepal due to its rugged topography, susceptible to landslides, very high relief, and intense precipitation during the monsoon period. Thus, there is a high need to protect the ecosystem together with the hydropower development by improving resilient hydropower infrastructure through good planning, design and sitting, construction, operation and maintenance, contingency planning, and restoring ecofriendly environment [52]. As per nature, extent, magnitude and duration of all observed adverse environmental issues/impacts on cultural and physical, chemical, biological and socio-economic during construction and operation phases of hydropower projects are highlighted in the **Table 1** below.

The climate change impacts significantly higher to water resources and hydropower sector like rising temperatures retreat glacier that in turn causes greater

Construction phase	Operation phase
a. *Physical environment*	
• Changes in site geomorphology, topography and land use patterns due to project structures • Construction access road and labour camps • Stockpiling of Construction Materials • Operation of quarry sites, crusher plant (noise and vibration, spoils from crusher, land instability) • Change in river morphology and drainage pattern • Landslide and soil erosion, and sedimentation due to excavation works • Generation of solid waste and spoil disposal • Leakage of oil, grease and other chemicals • Increase level of noise and vibration, change in air and water quality • Pollution to surface water due to siltation, inadvertent disposal of waste oils, wastewater, and solid wastes into the river • Contamination of groundwater springs, aquifers and hydrogeological conditions due leakage of chemicals • Slope destabilization and loss of top soil • Landslide Outburst Flood (LDOF)	• Changes in hydrology and sedimentation • Drainage disruption • Noise and vibration in powerhouse area • Change in water quality due to reduced flow and reservoir flushing • Leakage of oil, grease and other chemicals • Change in microclimate • Cumulative impacts • Landslide, flooding, LDOF • Generation of greenhouse gas • Change in river morphology and hydrological flow regime • Sediment flushing on dewatered section or reduced in-stream • Alternation of geomorphology upstream and downstream of the dam and the powerhouse • Generation of greenhouse gas • Generation of waste oil and used chemicals • Reduction downstream flow on riparian zone
b. *Biological Environment*	
• Loss of forest land, loss of forest and vegetation cover due to site clearance • Increase collection of firewood, timber, NTFPs and medicinal Plants • Habitat fragmentation and wildlife disturbance • Illegal hunting and poaching • Loss of aquatic species due to diversion of river • Increase fishing activity • Loss of biodiversity • Possible forest fire • Loss of or encroachment on critical habitats, protected areas, wetlands, and forestlands • Reduction of terrestrial and aquatic biodiversity • Impact on endangered, threatened species, protected and their habitats • Disturbance to aquatic habitat • Disturbance and/or removal of riparian vegetation	• Disturbance to fish migration, loss of spawning area, loss of habitat • Decrease aquatic flora and fauna in dewatered zone • Destruction wildlife habitat and wildlife movement • Forest encroachment and easy access to forest • Illegal hunting and poaching • Impact on terrestrial and aquatic ecology • Sudden release of water in downstream and reduction in river flow in the dewatered zone • loss of biodiversity and important species and introduction of invasive species • Inundation of flora and fauna • Forest fire inducement • Electrocution effects to wildlife • Impacts on protected species

Construction phase	Operation phase
c. *Socioeconomic and cultural Environment*	
• Land acquisition and private property • Impacts on livelihoods of affected families • Loss of standing crops • Physical and economic displacement of PAF • Occupational health and safety hazard • Increase in pressure on local health and sanitation facilities • Economic flux • Pressure on community infrastructures, social service facilities and resources • Impacts on social, cultural and religious rights • Impacts on gender and disadvantage groups • Impacts on springs and drinking water sources • Generation of solid and liquid waste • Increase demand on energy sources, firewood & timber • Demographic changes to the area and communities • Loss of livelihoods and loss of access to natural resources and cultural heritage	• Decrease or withdrawal in economic activities • Occupational, health and safety hazards, navigation risks • Reduction of agricultural land and food security • Sudden release of water downstream in the dewatered stretch impacts people and livestock • Headrace alignment and penstock crossing and project structures on springs and water sources • Dislocation/disturbance to foot trails along penstock alignment • increase in tourism activity and its associated pressure on local resources • Water use right and loss of cultural rights • Generation of solid and Liquid waste • Impacts of visitor and tourists • Impacts on use of community service facilities • Contamination of water sources HHs liquid and solid waste, sewage disposal •

Table 1.
Potential Adverse Impacts of Hydropower.

variability (and eventual reduction) in streamflow, and glacial lake outburst floods posing significant risk to hydropower facilities, infrastructure and human settlements. The climate induced risks to water resources and hydropower facilities related to flooding, landslides, and sedimentation, intense precipitation events, flow variation in dry season. Resiliency of hydropower assets is essential to face of increased frequency of extreme weather events and rapid changes in hydrological patterns to reduce the risk of climate-related disruptions as hydropower contributes significant reduction of GHG emissions. Hydropower plants prevents the emission of about 3 GT CO_2 per year (9% of global emissions) compared with conventional coal power plants [53].

4.4 Roads and transportation

The majority of the population in Nepal does not have reliable and adequate access on transportation services (**Figure 2**). Thus, the development of physical infrastructure services like roadways, railways, waterways, subways, flyovers and ropeways, transport (Air Transport) and transit management and its operation and implementation are rapidly growing. As per data, about 29031 km of roads (53 percent paved roads) and 1952 bridges in the country are in operation [54].

The availability of road infrastructure as per road density, Nepal stands at 139 km per 1000 km^2 [55], where 60% or more road network are concentrated in the lowland (Terai) areas. However, Nepal's 20% population residing in urban areas but Nepal considered fastest urbanizing country with annual growth rate of 5% on an average since 1970s [56]. The Global Competitiveness Report 2016 ranks, Nepal

Figure 2.
Temporary Means for Access on Mahakali River, Darchula Nepal.

130 of 138 in infrastructure [57]. Government of Nepal step-up to capital expenditure in infrastructure, in particular, sectors like water, communication, transportation and electricity from 2009 to 2016 received greater priorities [58].

An immense facility and services provides by the infrastructure development accessing agriculture, market, commerce, industry, and social sectors including education, health, communication, livelihood and quality of life but construction and maintenance works adversely affects natural environment. Nepal's young and fragile geology, poverty, vulnerable communities, construction of infrastructures brings significant impacts to the local and regional environmental settings. The major impacts associated with such developmental activities comprises; slop instability and slope failures, landslides and soil erosion, impacts on national parks, conservation areas and wildlife reserves, national forests and agricultural lands and interference with water courses, loss of terrestrial and aquatic biodiversity, river regime change, extraction of sand/gravel, irrigation facilities, run off and sedimentation, occupational health and safety, land acquisition, damages on cultural properties and effects on the unique life of ethnic and minorities communities.

4.5 Climate change and its consequences

The water, food, health, land, environment, infrastructures are vulnerable affecting by severe consequences of global climate change with irreversible loss of many species around the world. The increasing in extreme weather events damages infrastructures by natural disasters, storms and flooding. According to IPCC 2007, climate has been getting warmer since 1960 and this will continue. Global temperature will be increased at the end of the 21st Century in relative to the end of the 20th Century ranges from 0.6 to 4 °C and 3.3 °C in South Asia with the min-max range as 2.7–4.7 °C. Climate change projections for 1961–1990, in East Asia shows relative to the average for mean temperatures will be 1.9°–2.6 °C higher across the region in 2050, and 3.8°–5.2 ° C higher in 2090 [59]. The increasing pressure on natural resources in Asia associated with the rapid urbanization, industrialization, and economic development bringing challenges to protect the degrading environment. Asia comprises 51 countries/regions with land and territories, divided into six sub regions based on geographical position

and coastal peripheries. Forest carbon pools affected by the Climate change in some countries of the region and observed annual mean temperatures over South Asia in the past is increasing significantly about 0.75 °C per century. The physiology, phenology and distribution of plant and animal affecting by the climate change and also increase the risk of mortality and injury from wind storms, flash floods, coastal flooding and expected numbers of vector-borne diseases in the near future.

According to the 2020 edition of Germanwatch's Climate Risk Index, Nepal is ninth hardest-hit nation by climate calamities during the period 1999 to 2018, as one of the most vulnerable countries to the climate change effects [60]. The average annual maximum temperature has been increasing by 0.056 °C per year from 1971 to 2014 [61] and extremely increasing precipitation [62]. Similarly, more than 80% property had lost due to water disasters like floods, landslides and glacial lake outburst floods (GLOFs) [63].

Biodiversity is essential for Earths functioning ecosystem but growing human population, habitat loss and over exploitation of resources is the main factors to loss of biodiversity. According to IPBES, more than 1 million IUCN red list threatened species are risk of disappearing which includes 41% of amphibians, 25% of mammals, 34% of conifers, 13% of birds, 31% of sharks and rays, 33% of reef-building corals, and 27% of crustaceans [64]. The issue of global warming is concerned with the raising temperature by trapping earth's emissions in the atmosphere due to exposure of greenhouse gas emissions like carbon dioxide, nitrous oxide, methane, ozone, and water vapor and burning of fossil fuels. Increased lake and stream temperatures have significant implications affecting frequencies of disease in fish species and their altered growth, increased energy expenditures, thermal barriers on adult and juvenile migration, delayed and reduced spawner survival, altered egg and juvenile development, changes in biological productivity and altered species distribution [65].

The living components of ecosystems like plants, herbivores, carnivores, and soil organisms influences by the climate change in their functional ecosystem and characteristics in regards of energy and chemicals flow altering ecosystems properties and species distributions. The major resilience biodiversity in its ecosystems with variation of life on the earth interdepending webs of living organisms and physical environment provides us clean air, fresh water, food, resources and medicine. The humankind activities like air and water pollution, habitat destruction and fragmentation, and the introduction of invasive species likely to be exacerbated ecosystems. The valuable goods and services provided to the human societies by the ecosystem threaten to jeopardize the numerous economic and social values due to climate change effects [66]. The detrimental effects can be mitigated through preserving and maintaining habitat and species to maintaining overall ecosystem structure and species composition together with adapting biodiversity conservation strategy by reducing fragmentation and degradation of habitats, increasing connectivity among habitat blocks and fragments, and reducing external anthropogenic environmental stresses.

Nepal's water resources, public health and terrestrial ecosystems are most vulnerable sectors [67] with associated issues of food security, poverty reduction and environmental degradation. Adaptation of appropriate technology for changing cropping patterns, enhancing mitigation for emerging pests and disease and protection of changing landscapes of Nepal can cope with changing climatic pattern. Nepal's changing climatic pattern as experienced in temperature and mean precipitation, data on temperature trends from 1975 to 2005 showed 0.06^0 C rise in temperature annually with significantly decrease in mean rainfall on an average of 3.7 mm (−3.2%) per month per decade. The mean annual temperatures under various climate change scenarios for Nepal has projected to increase between 1.3–3.8 °C by the 2060s and 1.8–5.8 °C by the 2090s with reduction of annual precipitation to be in a range of 10 to 20% across the country [68]. The increased number of glacial lakes

in Nepal exceeds by 11% on an average by 38 km^2 per year and 29% about 129 km^3 ice reserve has estimated between the period of 1977 and 2010. Nepal is one of the most vulnerable countries to disasters and warming trends of Nepal is increasing as country's averaged mean temperature increases of 1.2 °C and 3 °C projected by 2050 and 2100 [69]. Glacier retreat and significant increases in the size and volume of glacial lakes of Nepal Himalayas making them more prone to Glacial Lake Outburst Flooding (GLOF). Climate change enhance more disaster's like landslides and soil erosion on excavation slopes, drainage disruption, flooding in roads, bridges and airport runways, drinking water sources and infrastructures of lowland areas so that roads, bridges, tunnels and other infrastructures are vulnerable to increased precipitation, groundwater levels, temperatures and winds. Transportation sector is affected by climate change and it contributes to greenhouse gas emissions. The mountain ecosystem and topography is highly affected by the climate events like high rainfall, accelerate surface run-off, increase flows in gullies, drainage channels, streams and rivers expose landslides and flooding, which instable road sections, bridges, and other infrastructures as well as inundations in lowland areas. Design and construction of climate resilient and environmental friendly infrastructures can support to reduce climate change impacts. Local microclimate can adapt through rod site plantation, bioengineering and climate resilient transportation system to reduce GHG level in atmosphere. The GHG emission of Nepal is around 0.027% of total global emissions and increasing GHG trend is from energy sector [70]. As Nepal is a party of UNFCCC supporting to limit temperature rise to well below 2 °C leading to 1.5 °C above pre-industrial levels in order to reduce the risks and adverse impacts of climate change.

Climate change and risks associated towards adverse impacts on ecosystems and biodiversity, water resources, food production, and infrastructure with global warming correlates to adapt reducing or avoiding adverse impacts and maximize positive consequences towards the risks. The adaptation process is complex towards risks posed by climate change and variability as Moser & Ekstrom 2010, stated adaptation process is constant of awareness and understanding, planning, implementation and monitoring and review [71]. To mitigate or avoid the projected impacts of climate change, adaptation urgently needed towards extreme changes and impacts that may occur [72]. According to Article of UNFCCC, evaluation of risk associate with climate change refers "dangerous anthropogenic interference with the climate system".

Although, Climate change affects biodiversity and ecosystem services that are not all negative, with some species either thriving or adapting. Climate change and associate impacts is an integrated and integral portion of the major developmental sectors of the nation that can be mitigated through effective implementation of mitigation tools. Environmental assessment a planning application for the development activities mainly propose mitigation measures as obligations within the legal framework for implementation but not fulfilled legal requirement seriously for monitor and implementation. Hence, the assessment strategy to address the likely environmental impacts of the planned sectoral projects is limited on fulfillment of the legal requirement.

5. Mitigation of environmental risks and climate change adaptation

5.1 Policy and legal instruments

Since 1980, Nepal has integrated environmental management related policies and strategies to address major consequences of developmental projects enunciating environment conservation related policies in the seventh plan [73]. In order to enforce policy and legal instruments for environmental protection from the project formulation stages for development strategy has considered avoiding or minimizing adverse effects on the ecological system. For this, EIA as a tool has adopted emphasizing

emerging environmental and ecological issues envisioned from developmental projects such as industry, tourism, water resources, transportation, agriculture, forest and other developmental projects. To institutionalize EIA system in Nepal, eighth plan period [74] has remarkable contribution adopting and implementation of National EIA Guidelines of 1993 [75] and enforcement of Environment Protection Act, 1997 and the Environment Protection Rules, 1997 [76]. Nepal has enacted a number of regulatory measures for the consideration of the environmental aspects in the development project and programme, however still inadequate mainstreaming of biodiversity into national development plan and programmes. Generally, EIA implementation in developing countries appears to work best if legal and institutional arrangements have evolved gradually through an "organic" process, rather than one "imposed" from the outside [77]. The main Plan, Policy, Act, and Regulations related to sectoral projects, those addressed major environmental issues are outlined below:

- National Environment Policy 2019 aims to control pollution, manage wastes and promote greenery so as to ensure citizens‟ right to live in a fair and healthy environment. The policy was framed to guide the implementation of environment related laws and other thematic laws, realize international commitment and enable collaboration between all concerned government agencies and other sectors on environmental management actions. This policy aims to lessen and prevent all types of environment pollutions, manage wastes emanated from all sectors including home, industry and service, expand parks and greenery in urban area and ensure environment justice to the pollution-affected population. In order to meet the policy goals and objectives, the policy has specified special measures, including setup of effective systems for checking and reducing pollution of all types, encouragement for the use of environment-friendly technology in industry, hospital and vehicles, regulation of harmful pesticides in production and protection of human health from unauthorized food intake.

- Government of Nepal enacted Environmental Protection Act 2019 replacing previous EPA 1997 new amendments. The EPA 2019 empowers environmental protections; preserve right to clean and healthy environment of the society, maintain adaptation between environment and development, reduce adverse impacts on natural environment and biodiversity and climate change adaptation. According to the act, permission will be granted to such projects to use part of national forest if there are no other alternatives and it does not cause significant adverse impact on the environment. As such, it calls for such projects to go through environmental assessment procedure adhering with the prevailing act to ensure that it has clear provisions for compensating the forestland acquired and trees felled by such projects. Provisions relating to forest conservation area and its management, ecosystem service and payment for ecosystem service and establishment of forest development fund are some new highlights of this act. This act provides for establishment of a forest development fund to implement the objectives of this act, conserve and enhance forest. The provisions relating to management of forest as government managed, community, leasehold and religious forest are retained in this act.

  Considering previous Environment Protection Regulation (EPR), 1997 and its amendments, EPR endorsed EPR 2020 under the provisions of the EPA 2020. The EPR adopts the environmental assessment criteria mentioned in the National Impact Assessment Guideline 1993. However, the EPR establishes the administrative framework for assessing, exhibition and determination of EIA/IEE, in terms of issues needing to be addressed and the format/layout of the EIA/IEE document. Schedule 1, 2 and 3 listed proposal to be conducted

Brief Environmental Study, Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) studies of sectoral projects respectively. The criteria for screening sectoral projects to conduct environmental studies before commencement of the projects has included Forest Sector, Industrial, Mine and Minerals, Road, Residential, Buildings, settlement development and Urban development areas, Water Resource and industry, Tourism, Drinking Water, Solid Waste Management, Agriculture, Health and Education Sectors. Besides these provisions, Section 4 Climate Change, Rule 25 has defined preparation of National Report by the Ministry regarding climate change situation, impacts and risks in every 5 years period. Rule 26 of same section provisioned Ministry should prepare National Adaptation Plan for each 10 years period and Rule 27 provisioned implementation of Mitigation Plan. The detailed framework of EPR 2020 shown in the **Figure 3**.

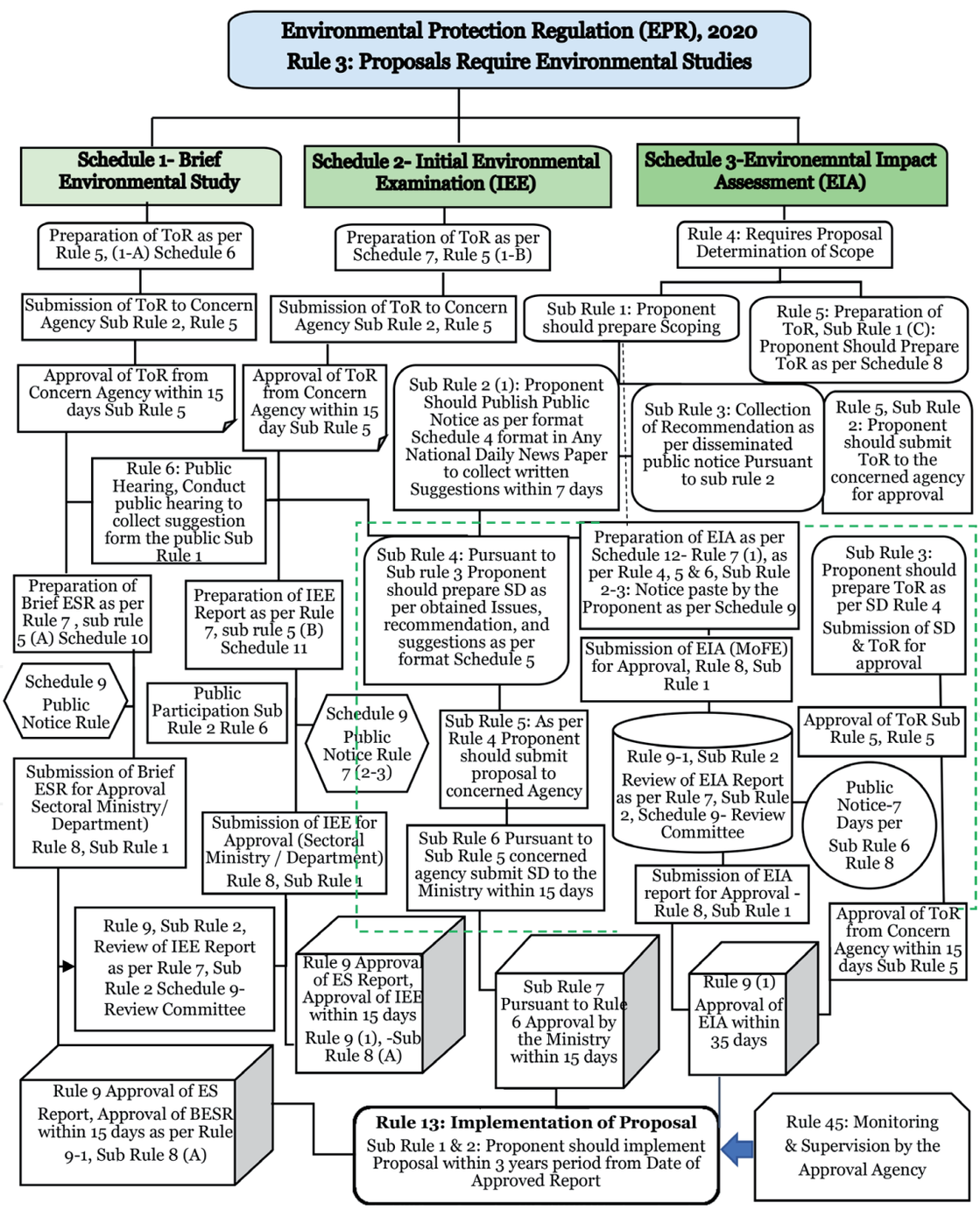

Figure 3.
Legislative framework for environmental assessment process, EPR 2020.

- The Nepal Biodiversity Strategy and Action Plan (NBSAP) 2014–2020 envision a conserved biodiversity contributing for sound and resilient ecosystems and national prosperity.

- The Forest Rules 1995, enforced as per the Forest Act 1993, has categorized number of medicinal herbs and non-timber plants or the timber species with timber use parts for legal trade. Forty-three species are listed to be licensed for their root collection; 20 species for bark; 31 species for leaves; 24 species for flower and fruits; 65 species for fruit and seeds; 12 species for whole plants; 10 species for resin, gums and lac; and other 29 herbs for whole or parts of the plants.

- Nepal became a contracting party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITIES) 1973 on June 18, 1975. That aims to control the trade of certain wildlife species to prevent further endangered species of their survival. CITIES classified species according to the following three criteria-Species threatened with extinction; Species, which could become endangered, and Species that are protected. As Nepal is a signatory to the convention related to species conservation, attention should be given to evaluate the impacts of the project activities on meeting their obligation. It is relevant to environmental assessment studies that species protection list could also be used to evaluate the significance of the identified and predicted impacts for practical mitigation. Plant and species of wildlife under legal protection provides a basis to purpose EMPs for their conservation and for least damaging them during project implementation.

- National Climate Change Policy (NCCP) 2019 underlined thematic areas towards developing a resilient society by reducing the risk of climate change impacts. The policy has integrated sectoral polices and strategies on agriculture and food security, forest, biodiversity and watershed conservation, water resource and energy, rural and urban habitants, industry, transport and physical infrastructure, tourism and natural and cultural heritage, health, drinking water and sanitation, disaster risk reduction and management, gender equality and social inclusion, livelihoods and good governance, awareness raising and capacity development, research, technology development and expansion and climate finance management.

- Hydropower Development Policy 2001 outlines the overall objectives and strategies for hydropower development in Nepal. In addition, National Transport Policy 2001/2002 highlights transport infrastructure development through environment-friendly green road.

- National Forest Policy 2018 defines Nepal's economic, social, and cultural prosperity through a well-managed forest and a balanced environment including production and value addition of forest-based products and services and equitable distribution of the benefits from sustainable and participatory management of the forest, protected areas, watershed, biodiversity and wildlife.

5.2 Mitigation strategy and adaptation

Climate change and risks associated towards adverse impacts on ecosystems and biodiversity, water resources, food production and infrastructure with global

warming correlates to adapt reducing or avoiding adverse impacts and maximize positive consequences towards the risks. The adaptation process is complex towards risks posed by climate change and variability as Moser & Ekstrom 2010, stated adaptation process is constant of awareness and understanding, planning, implementation, and monitoring and review [71]. The main services provided by the forests is carbon removal from the atmosphere (carbon sequestration) and the long-term storage of this carbon in biomass, dead organic matter, and soil carbon pools. An estimated 55% (471 Pg C) stored in tropical forests out of the global forest carbon stocks of which more than half is stored in biomass [78]. To mitigate or avoid the projected impacts of climate change adaptation, urgently needed towards extreme changes and impacts that may occur [72].

According to Article of UNFCCC, evaluation of risk associate with climate change refers "dangerous anthropogenic interference with the climate system" [79]. The Convention on Biological Diversity (CBD) has defined ecosystem-based adaptation (EbA) in 2009 as use of biodiversity and ecosystem services as part of an overall strategy to help people adapt to the adverse effects of climate change and EbA projects have proliferated in 2015. As the EBA uses a range of opportunities for the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change, Nepal had adopted Ecosystem-Based Approach (EBA) for priority ecosystems of major ecological regions. To build resilience using an ecosystem management approach in vulnerable developing countries by increasing institutional capacity, mobilizing knowledge and transferring appropriate best-practice adaptation technologies (**Figure 4**).

The developmental activities are the main drivers of biodiversity loss, proper implementation of appropriate sustainable mitigation measure against adverse

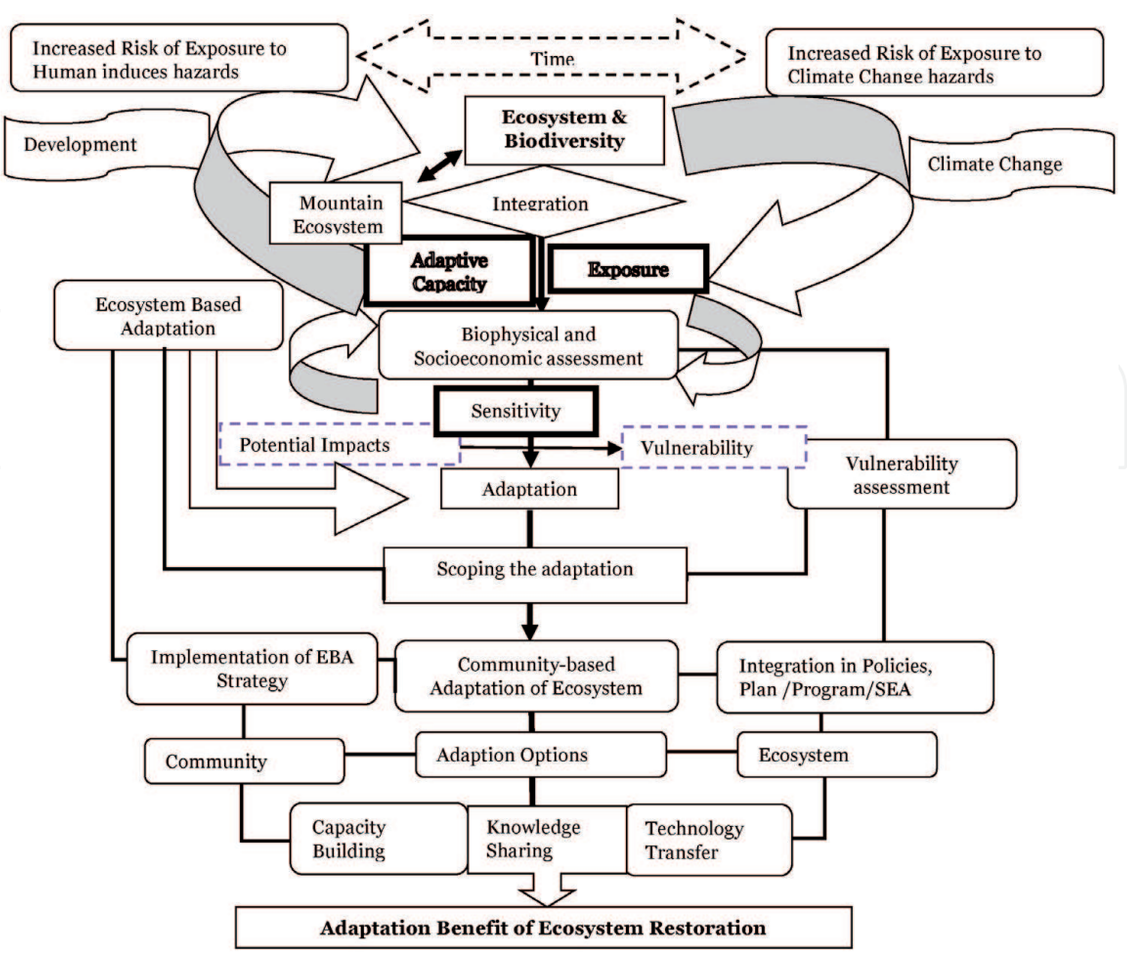

Figure 4.
Schematic diagram of ecosystem based adaptation.

impacts can support to maintain ecosystems and biodiversity loss. Although, Climate change influences on biodiversity and ecosystem services but not all are negative, with some species either thriving or adapting. Although, environmental assessment a planning application for the development activities generally propose mitigation measures as obligations within the legal framework for implementation. However, the assess¬ment strategy to address the likely environmental impacts and mitigation of the planned sectoral projects is limited including an effective implementation of EMP. The major mitigation measures for developmental projects are presented in the **Table 2**.

Likely impacts	**Mitigation measures**
a. *Air Quality*	
1. Depletion of ozone layer and climatic change due to emission of some gases (SO_2, CO_2, NO_2, Fluoride, CO, CFCS etc.) to the Atmosphere	• Control the emission of SO_x, NO_x, Co and other applicable chemicals by scrubbing with water or alkaline solutions, incineration or absorption by other catalytic processes • Recycle wastes to reduce the amount of pollutants released to the atmosphere choose environmentally friendly processes, technologies, or raw materials • Treat effluent gases to reduce the amount of pollutants. • establish treatment plant
2. Reduction of air quality due to dust	• Control particular matters by scrubbers, fabric filter collectors or electrostatic precipitators • choice of environmentally friendly processes, technologies or raw materials reduce the amount and significance of pollutants watering of the area form which dust is generated
b. *Ecosystem and Biodiversity*	
Loss of flora and fauna	• locate projects far away from sensitive areas • carry out necessary rehabilitation measures when phasing out a project
Habitat Fragmentation -stability and health of an ecosystem	• plant with native species in vicinity of a project and adjacent areas to wildlife to provide additional habitats and migration routes/corridors for local animals • fence wildlife areas to avoid people interference
Direct killing of animals like collisions with vehicles	• At important areas use of tunnels/bridges reduces interference and collision rates fencing or plant barriers can reduce the interference of human beings and traffics to wildlife • Take measures, like speed break on roads to reduce the speed of vehicles where road crosses protected areas
Disturbance of ecosystem because of extraction of sand, boulders, gravel or rock	• Avoid extraction of sand, gravel boulders from riverbed, bottom/water bodies • use alternative site to exploit the resources avoid the use of dynamite/explosive in water bodies • avoid construction materials during breeding seasons in both water and terrestrial ecosystems
Exploitation of natural resources (flora and fauna) because of immigrants to project area	• before the establishment of projects, planting appropriate tree species, which can be used for different purposes, to minimize burden on the sitting natural resources • use alternative energy resources and construction materials, use proper waste management technology • Make clear demarcation between the resource and project area.

Likely impacts	Mitigation measures
Flora and fauna in wetlands are affected	• avoid the excessive clearance of vegetation from stream banks locate projects as much as far as possible from wetlands • avoid the releaser or minimize the use of hazardous chemicals in the catchments of vulnerable wetlands • If possible, the project should not modify water flow/course use soil and water conservation measures in the catchments to reduce siltation
Introduction of new species or change of cultivation may cause for development of pests, diseases, or weeds.	• Research on invasive exotic species should be carried out in enclosed areas • avoid the use of invasive exotic species for landscaping, reforestation or for other purposes • control the importation of uncertified seed or germ plasm to the region to avoid import of plant pests/disease
Direct or indirect killing of aquatic and terrestrial animals spreading of pesticide/insecticide for different purposes.	• Use integrated pest management to avoid mass killing of animals the concentration and length of time to chemicals should meet standard criteria • use appropriate and trained man power for application of chemicals avoid the use of very poisonous pesticides in particular, on fields sloping down to watercourses during rain seasons with heavy precipitation apply pesticide, when a number of fauna are at the side
Contamination or use of polluted water may affect wild life and nearby communities to the project area.	• use of chemicals or disposal of wastes in a proper way reduce the impact, handling of unused/used poisonous chemicals until they are treated and disposed properly be sure that effluents are treated to the standard before joining water bodies • Avoid the use of very poisonous pesticides in particular on fields sloping down to watercourses during seasons with heavy precipitation • Proper disposal of expired chemicals prevents the potential impacts on flora and fauna • proper disposal of wastes reduces siltation and pollution of water
Improper use of modern biotechnology or introduction of genetically modified varieties to the region may lead to genetic erosion	• Regulate/control importation of varieties to avoid genetic erosion • Regulate import of species to avoid the spoiling of the natural means of existence of existing fauna • Avoid the use of invasive exotic species for landscaping, reforestation, research or for other purposes • Care has to be taken in activities related to modern biotechnology to reduce/avoid the impacts on indigenous species or genetic erosion
Change of the living condition of fish when its migration route is blocked by constructions e.g. dams/ reservoirs	• design carefully diversion wears, dams/reservoirs etc. to allow aquatic species to swim against the current • Use filters not to get away fishes to irrigation canals construct ladders so that the fishes jump and migrate against the flow of the water
Water logging may affect the flora (especially deep-rooted plants) and fauna of the area	• digging of canals to lower the water table planting high water consuming species minimizing over irrigation
Exhaustion of resources	• restrict or limit the optimum amount to be exploited/harvested according to the management plan done for the specific resource use recycling methods

Likely impacts	Mitigation measures
c. *Water Resources/bodies*	
Flooding, channel modification, river canal siltation	• leaving sufficient enough buffer zones of undisturbed vegetation between the site of the project and water bodies • use water flow speed reduction measures e.g. soil conservation measures • Plan carefully to avoid the change/modification of the previous channel flow/natural flow of water
Reduction/lowering of surface or groundwater table	• locate those water-consuming projects, if possible, in areas where availability of ground or surface water is not a problem • choose the most appropriate techniques to minimize the amount of water consumed ensure that the utilization of groundwater is within the capacity of natural system to replenish itself re-use the recycled wastewater
Excess increment of nutrients in water bodies (eutrophication).	• sitting projects far away from susceptible areas to erosion in order to reduce chemical pollution of water bodies • carry out soil conservation measures • leaving sufficient enough buffer zones of undisturbed vegetation between the site of the projects and water bodies • avoid direct waste disposal into or near water bodies • reduce the amount of inlet of both chemical and biological fertilizers to water bodies
Pollution of surface and groundwater through direct or indirect addition of toxic chemicals.	• sitting projects far away from susceptible areas to erosion in order to reduce chemical pollution of water bodies • leaving sufficient buffer zones of undisturbed vegetation between the site of the project and water bodies • install silting basins to reduce silt, pollutants and debris from runoff before it is discharged to adjacent water bodies • Monitoring pipeline systems and impoundments for leaks to reduce contamination of groundwater. E.g. Preparing waterproof waste water collectors • monitor sites even after the project has been closed (as necessary) • reclaiming landscapes where devastating activities have been taken place to reduce water pollution • recycling wastes to reduce water pollution • use treatment techniques especially in industrial activities • choice of the most appropriate technique, replacing processing equipment dispose safely/properly expired toxic chemicals
Increment of suspended solids (turbidity) in water bodies through soil erosion or direct release of waste from different activities.	• sitting projects far away from susceptible areas to erosion in order to reduce siltation, turbidity and chemical pollution of water bodies carry out soil conservation measures • Separation of buffer zone between project sites and water bodies for undisturbed vegetation • installing silting basins to reduce silt, pollutants and debris from runoff before it is discharged to adjacent water bodies
Increment of the amount of silt/sediment in downstream area including agricultural land, reservoirs, etc.	• Minimize the area of ground clearance; provide good vegetative cover or; control the volume and speed of water flows • Careful design/plan of projects can avoid soil erosion; carry out soil conservation measures. • Leaving sufficient buffer zones of undisturbed vegetation between the site of the project and water bodies

Likely impacts	Mitigation measures
d. *Soil*	
Soil erosion and loss of nutrients due to different activities	• Replanting right species of trees, shrubs and grasses in a right time on disturbed areas. Minimize the area of ground clearance. • Careful design/plan of projects carry out soil conservation and or agro-forestry measures. Reducing harvest removal.
Soil compaction due to mechanization and machineries.	• Using appropriate machineries/mechanization in appropriate time. Planting leguminous plants improve soil structure. • improve soil structure by planting species that improve soil structure or by adding organic matter
Salinization due to irrigation with saline water	• adding organic matter/neutralizing planting salt tolerant species
Soil acidity	• reduce the addition of artificial/organic chemical adding alkaline substance like lime appropriate use/disposal of chemicals
Imbalance of biological activities as a result of contamination of soil with toxic chemicals and loss of organic nutrients due to soil erosion	• Appropriate use of wastes/toxic chemicals take any measures that are used to minimize loss of nutrients. Adding organic matter (green maturing, compost). • promote cleaner production (preventing/minimizing waste)
Productive topsoil covered by proposed activities or removal of productive top soil for temporary or permanent purposes	• Collect and reuse the excavated top soil to form a superficial layer. Conversions of borrow pits and spoil dumpsites in to scenic lookouts. • Use vertical space than horizontal.
e. *Human Health and Safety*	
Transmission of disease between human and from plants/animals to humans	• sanitary or precaution measures can be accomplished through a comprehensive health awareness campaign curative measures should be in place
Fire, explosions, emission of toxic gases, vapors, dust, emission of toxic liquid, radiation and their cumulative effects badly affect human health in and around the project	• establishing projects far away from settlements • Curative measures have to be in place if accidents from different activities can happen. • Provide fire proofing of structures, safety buffer zones around the plant boundary, escape routes and others. • Store properly easily flammable/explosive gases or toxic chemicals. • preventive/protective instruments have to be provided
Health effects on workers due to fugitive dust, material handling, and noise, mechanical or chemical contact can be occurred.	• Prevent accidents through proper design of projects train responsible personnel how to properly handle chemicals; use protective measure, for example ear/eye masks etc.
Noise and congestion may be created and pedestrian hazards could be aggravated by heavy trucks	• Site selection can be taken as preventive measures.
Death and injuries to human beings and damages to property could be happened in factories, roads etc.	• facility should implement a safety and health program designed to identify, evaluate, monitor and control health hazards • Site selection can be taken as a preventive measure to minimize risk of accidents especially in road projects. • prevent accidents through proper design of projects use protective measure, for example ear/eye masks etc.
Extraction of sand or gravel may from unnecessary pond, which creates suitable condition for malaria and water vector borne disease	• Sanitary or precaution measures can be accomplished through a comprehensive health awareness campaign. • Avoid stagnating water and give consecutive awareness to reduce the occurrence of malaria and other related diseases

Likely impacts	Mitigation measures
In mining activities workers are injured when rocks/soils are collapsed	• Proper design has to be done well in such a way that rocks does not collapse. • curative measures have to be in place

Table 2.
Mitigation measures for some of the environmental impacts.

6. Conclusion

The dimensional impacts of climate change threaten species biodiversity and its functional characteristics influencing the ecosystems. This can be mitigated through implementation of mitigation and adaptation plan for actions minimizing climate change induced risks targeting to support biodiversity and entire ecosystem services. Mitigation of greenhouse gases emission through reduction in use of fossil fuel, promotion of clean energy and increase in the rate of carbon uptake through natural ecosystems is the solution. Similarly, implementation of strategic action plans, afforestation/reforestation, agroforestry, land use management, promotion of renewable energy (hydropower, biomass, wind power, solar power etc.) as well as effective implementation of plan, policy and conventions can contribute to address the global climate issue and its impacts. Likewise, minimizing negative consequences and enhancing opportunities adjusting or accommodating to climate change induced impacts can also increase the adaptive capacity of species and ecosystems. This can lead plummeting non-climatic stresses, such as pollution, over-exploitation, habitat loss and fragmentation and invasive alien species, wider adoption of conservation and sustainable use practices including through the strengthening of protected area networks and facilitating adaptive management through strengthening monitoring and evaluation systems.

Nepal has adopted several policies, strategies and EIA tool to address emerging environmental and ecological issues envisioned from developmental projects but threats on ecosystem and biodiversity and degrading rate of natural environment is constant in an alarming rate. The emerging agenda of the country like promotion of renewable energy, enhance capacity of local communities' adaptation and resilience, widen carbon storage through sustainable forest management, and reduce carbon emissions can support to the consequences of climate change issues.

To conserve biodiversity including terrestrial, freshwater and marine ecosystems, restoration of degraded ecosystems, potential impacts of developmental projects can be avoided, reduced and compensate together with pollution control. This can support restore biodiversity and sustain utilization of ecosystem services however, magnitude of climate change effect difficult to adapt all dimension of ecosystems.

Author details

Ramesh Prasad Bhatt
Institute of Ecology and Environment, Kathmandu, Nepal

*Address all correspondence to: drrameshbhatta@gmail.com

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