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Climate change effects on physico-chemical parameters for testing of water in Nepal

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Abstract
Water is most indispensable requirement for all living organisms and any alterations in water may lead to the issue of survival for these organisms. Due to increase in population, industrialization and urbanization, large quantities of sewage and industrial wastewater are discharged into lake has significantly contributed to the pollution of the lake. Nepal is one of the most water-abundant countries in the world, with 6000 rivers, total mean annual runoff of 224 km3 and per capita water availability of 9000 m3. However, the hydrology of Nepal is primarily monsoon-driven, and about 85% of the rainfall happens in June–September. The temporal variability of rainfall and runoff is hence very high, and the problems of excess water during the monsoon, and water scarcity during the dry season, affect all aspects of life in the country. Nepal suffers from different types of water-induced disasters such as soil erosion, landslides, debris flow, flood, bank erosion etc. due to its rugged topography, weak geological formations, active seismic conditions, occasional glacier lake outburst, floods and concentrated monsoon rains associated with unscientific land utilizations. Climate change is a major environmental threat and likely one of the most important challenges of our time. In particular, climate extremes such as heat waves can have a significant negative effect on society. Climate change is a risk multiplier that will put greater pressure on biodiversity preservation, land use planning, forest-health and quality, and water resources. Climatic change increases the variability and magnitude of natural weather events and increase uncertainty about adequate and appropriate natural. All above impacts have resulted in the deterioration of water quality of river and lakes. It gives the clue to develop appropriate management strategies by municipal authorities. Hence it is essential to examine the quality of water by different parameters as stated above before using the water.

Keywords: Water, climate change, physico-chemical, Nepal

1. Introduction

Nepal is the fastest urbanizing country in South Asia and Kathmandu Valley is the fastest growing metropolitan area in the region [1]. The valley has observed rapid urbanization and population growth in last few decades. The annual population growth rate is in the Valley 4.3 % and the annual motorization rate is 12% [2]. The valley is especially vulnerable to air pollution due to haphazard urbanization, rapid motorization, valley centric industrialization and its topography [3]. Kathmandu is the most rapidly growing metro region in South Asia. Nepal faces a number of physical and human challenges in recognizing the benefits associated with water resources development and management. The rugged topography, young mountains, and monsoon climate all combine to produce high rates of runoff, erosion and sedimentation. On the other hand, human activities have resulted in impacts to forests, soils and terrestrial and aquatic species and habitats. Increasing population pressure and demand for agricultural land often conflict with plans for protection of the natural environment. In urban areas, waste water, solid waste and air pollution have seriously degraded living conditions [4]. Poverty and environmental degradation are closely related in Nepal.

In Nepal there are eight different ministries working in water-related issues. These are Energy, which is responsible for electricity generation and overall power-sector development; Irrigation, which is in charge of irrigation development; Urban Development, which is responsible for drinking water supply and water sanitation provision; Agriculture and Cooperatives, which is responsible for agricultural crop production; Forest and Soil

Conservation; Science, Technology and Environment; Physical Infrastructure and Transport; and Federal Affairs and Local Development, which is in charge of local infrastructure development in the rural areas [5].

Nepal suffers from different types of water-induced disasters such as soil erosion, landslides, debris flow, flood, bank erosion etc. due to its rugged topography, weak geological formations, active seismic conditions, occasional glacier lake outburst, floods and concentrated monsoon rains associated with unscientific land utilizations [6]. These phenomena induce severe impacts on the vital infrastructures of the nation such as roads, hydropower, irrigation and drinking water facilities causing loss of agricultural lands, properties and human lives posing a severe threat to the sustainable development of the country. Thus, water is most indispensable requirement for all living organisms and any alterations in water may lead to the issue of survival for these organisms. Good quality of water is essential for living organisms. The quality of water can be assessed by studying its physical and chemical characteristics. Because of vast population and negligence of human being the quality of water is being deteriorated day by day [7].

1.1 Water resources management in Nepal

Water is the most plentiful natural resources in Nepal, major sources being glaciers, rivers, rainfall, lakes, and ponds. 42% of the people reside in major basins, 18% in medium and 40% in Terai covered by Southern rivers, this basin wise distribution of population and water availability has resulted in some basins having excessively surplus water availability and some with water deficit. The glaciers of the Himalayas ensure a year round water supply to millions of people in South Asia but climate change has impacted glacial systems tremendously; 67% of glaciers being retreating at a startling rate as per [8, 9]. Moreover, it covers 2.86% of Nepal's area.

Nepal is one of the most water-abundant countries in the world, with 6000 rivers, total mean annual runoff of 224 km3 and per capita water availability of 9000 m^3. However, the hydrology of Nepal is primarily monsoon-driven, and about 85% of the rainfall happens in June-September [10]. The temporal variability of rainfall and runoff is hence very high, and the problems of excess water during the monsoon, and water scarcity during the dry season, affect all aspects of life in the country. Over 80% of Nepal's population depends on subsistence agriculture for their livelihood [11]. Despite vast groundwater reserves in the Terai, tube well development and use remain limited, and access to groundwater is particularly difficult for the marginal (< 0.5 ha) and tenant farmers who constitute the majority of cultivators. As a result, vast tracts of land remain fallow during the winter and summer dry seasons. Thus, the issue of improved water resources development and management looms large for the future of the country [12].

Due to increase in population, industrialization and urbanization, large quantities of sewage and industrial wastewater are discharged into river has significantly contributed to the pollution of the river [13]. Water quality assessment studies on the river were conducted from time to time for the last two decades by several agencies and implemented pollution control measures to rejuvenate the river. According to WHO estimate about 80% of water pollution in Nepal is due to domestic waste. The improper management of water systems may cause serious problems in availability of drinking water [14]. Water resource is most often polluted by industrial effluents. When waste from different industry are discharged without proper treatment in to the water. The physical, chemical and biological characteristics of water are altered in such a way that they are not useful for the purpose for which they are intended [15].

1.2 Climate Change effects in Water resources of Nepal

The climate change phenomenon refers to seasonal changes over a long period with respect to the growing accumulation of greenhouse gases in the atmosphere. Tackling this phenomenon is of utmost importance given the pivotal role that climate plays in the formation of natural ecosystems and the human economies and civilizations on which they are based [16]. Recent studies have shown that human activities since the beginning of the industrial revolution manifested in fossil fuel consumption for power generation, land deforestation for agriculture, and urban expansion have contributed to an increase in the concentration of carbon dioxide in the atmosphere by as much as 40%, from about 280 parts per million in the pre-industrial period, to 402 parts per million in 2016, which in turn has led to global warming [17]. Indeed, the Intergovernmental Panel on Climate Change has described anthropogenic climate change as "inevitable" in view of the numerous changes observed in the temperature of the atmosphere, oceans, and sea ice, in addition to some extensive changes in the climate cycle over the course of the 20th century [18]. Several parts of the world have already experienced the warming of coastal waters, high temperatures, a marked change in rainfall patterns, and an increased intensity and frequency of storms. Rising sea levels and temperatures are expected to be an increasing trend. Climate change is a risk multiplier that will put greater pressure on biodiversity preservation, land use planning, forest-health and quality, and water resources [19]. Climate change is already greatly affecting water availability, changing the pattern of the monsoon, provoking both droughts and floods, changing water tables, and changing freshwater storage in glaciers. Climatic changes increase the variability and magnitude of natural weather events and increase uncertainty about adequate and appropriate natural [20].

Water is arguably the most important of all natural resources; it is essential to life, and in many ways it is life. Through the global water cycle, water is literally the connection between the heavens and the earth. From an international development perspective, water is a cross-cutting theme par excellence: it is in one way or another part of virtually all "sectors" (agriculture, health, energy, drinking water & sanitation, environment, governance, the combination of these into economic growth, both urban & rural development, etc.) and linked to many other of the most important cross-cutting themes: gender & social inclusion, community participation, the involvement of both civil society and the private sector. Water is also an important theme in a vertical sense as a key natural resource that is at the center of human and power relations and dynamics between the individual, family and community up through scales to the national level and from the national level up through the regional level (i.e. Nepal's relations with China, India and Bangladesh) to a global level [21].

Nepal is often lauded as the second most "Water Rich" country in the world (after Brazil), yet this belies the fragile nature of its water systems and the extreme seasonal variation in its water availability. Poor management of the riverine forests and riverbanks, as well as unregulated riverbed mining have led to increasing levels of sedimentation, blocking dams and in some cases displacing entire rivers. Exacerbating this is municipal and rural, point and non-point source, pollution of waterways. Endemic and rare species make up contribute to the incredible biodiversity of Nepal's rivers and other wetlands, but they are poorly studied and understood, and are likely to be under enormous threat due to those previously mentioned challenges [22].

Despite the clear importance of sustainable water resources management to Nepali development, very little is actually known about water resources management at a large scale, and the status of freshwater biodiversity in the hills and mountains, particularly in the face of climate change. Furthermore, water is managed by approximately 10 different ministries (out of a total of 27) dealing with different aspects of water use. The ministries, and even departments within ministries, do not coordinate sufficiently, and there is very little joint planning [23].

1.3 Adaptation to Climate Change

Adaptation to climate change in developing countries like Nepal is vital and has been highlighted by them as having a high or urgent priority. Although uncertainty remains about the extent of climate change impacts, in many developing countries there is sufficient information and knowledge available on strategies and plans to implement adaptation activities now. However, developing countries have limitations in capacity making adaptation difficult. Limitations include both human capacity and financial resources [24].

Adapting to climate change will entail adjustments and changes at every level from community to national and international. Communities must build their resilience, including adopting appropriate technologies while making the most of traditional knowledge, and diversifying their livelihoods to cope with current and future climate stress [25]. Local coping strategies and traditional knowledge need to be used in synergy with government and local interventions. The choice of adaptation interventions depends on national circumstances. To enable workable and effective adaptation measures, ministries and governments, as well as institutions and non-government organizations, must consider integrating climate change in their planning and budgeting in all levels of decision making [26]. Adaptation to climate change must also occur through the prevention and removal of maladaptive practices. Maladaptation refers to adaptation measures that do not succeed in reducing vulnerability but increase it instead. Examples of measures that prevent or avoid maladaptation include: better management of irrigation systems; and removal of laws that can inadvertently increase vulnerability such as destruction of mangroves and relaxation of building regulations on coasts and in floodplains [27].

Nepal has a wide variation of climates from subtropical in the south, warm and cool in the hills to cold in the mountains within a horizontal distance of less than 200 km. Generally, there are four seasons in Nepal: summer monsoon (June-September), post-monsoon (October-November), winter (December-February) and pre-monsoon (March-May) [28]. The climate of Nepal is dominated by monsoon and about 80% of annual precipitation occurs during the summer monsoon [29]. The amount of precipitation varies considerably from place to place because of the non-uniform rugged terrain. However, the amount of rainfall generally declines from east to west [30].

The length of the regular and systematic observations of climatological and hydrological data in Nepal is only about 50 years. The longest systematic temperature and precipitation data have been available for Kathmandu since 1921 recorded by the then Indian Embassy under British rule [31]. The existing climatological and hydrological stations are generally located at the lower elevations. The high mountain areas with very low population density and negligible economic activities are mostly left without any hydrological and meteorological stations [32]. So, even the available climatic data are also very sparse, poorly representing the high mountain areas. The meteorological observations in high mountain areas were only initiated in 1987 after the establishment of theSnow and Glacier Hydrology Section in the Department of Hydrology and Meteorology of Nepal [33].

The oldest temperature records available so far for Kathmandu and its surroundings were documented by Hamilton during his stay in Nepal from April 1802 to March 1803, but this information does not provide the information on site and equipment of measurement [34]. There is no continuous temperature record at all for the subsequent years up to 1921. The studies on analyses of the temperature records of Kathmandu for the period of 1921-1994 showed a similar temperature trend as that of 24º-40ºN of the earth, i.e. a general warming trend till 1940s, a cooling trend during 1940s-1970s and a rapid warming after the mid 1970s [35]. Sharma *et al*. [36] indicated that the increasing trend of average temperatures during that period was primarily due to the increasing trend of maximum temperatures and there was no increasing trend of minimum temperatures. The temperature trends for 1971-1994 as analysed by Shrestha *et al*. [37] widely varied among the geographical regions and the seasons in Nepal. Low-elevation areas in the south showed a slower warming rate than the high mountain areas in the north. Average annual temperatures in the Terai regions in the south increased by about 0.04ºC/yr, whereas those in the middle mountain areas in the north increased by about 0.08ºC/yr (ibid). Similarly, the pre-monsoon season (March-May) showed the lowest warming rate of 0.03ºC/yr, while the post-monsoon season (October-November) showed the highest one of 0.08ºC/yr [38].

2. Some Physico-Chemical Parameters for Water Analysis

It is very essential and important to test the water before it is used for drinking, domestic, agricultural or industrial purpose. Water must be tested with different physico-chemical parameters. Selection of parameters for testing of water is solely depends upon for what purpose we going to use that water and what extent we need its quality and purity. Water does content different types of floating, dissolved, suspended and microbiological as well as bacteriological impurities. Some physical test should be performed for testing of its physical appearance such as temperature, color, odour, pH, turbidity, TDS etc, while chemical tests should be perform for its BOD, COD, dissolved oxygen, alkalinity, hardness and other characters. For obtaining more and more quality and purity water, it should be tested for its trace metal, heavy metal contents and organic i.e. pesticide residue. It is obvious that drinking water should pass these entire tests and it should content required amount of mineral level. Only in the developed countries all these criteria's are strictly monitored due to very low concentration of heavy metal and organic pesticide impurities present in water it need highly sophisticated analytical instruments and well trained manpower. Following different physic chemical parameters are required to for monitoring quality of water in Nepal.

a. Physical Tests

Temperature –

Temperature can exert great control over aquatic communities. If the overall water body temperature of a system is altered, an aquatic community shift can be expected. In water above 30degree C, a suppression of all benthic organisms can be expected. Also, different plankton groups will flourish under different temperatures. For example, diatoms dominate at 20 - 25 degrees C, green algae dominate at 30 – 35 degrees C, and cyano-bacteria dominate above 35 degrees C.

2.2 Colour

Color is vital as most water users, be it domestic or industrial, usually prefer colorless water. Determination of colour can help in estimated costs related to discoloration of the water.

2.3 Light transmission

This measurement uses a light meter (photocell) to determine the rate at which light transmission is diminished in the upper portion of the lake's water column. Another important light transmission measurement is determination of the 1% light level. The 1% light level is the water depth to which one percent of the surface light penetrates. The 1% light level is considered the lower limit of algal growth in lakes and this area and above is referred to as the euphotic zone.

2.4 *pH-*

pH is the measure of the acidity of a solution of water. The pH scale commonly ranges from 0 to 14. The scale is not linear but rather it is logarithmic. For example, a solution with a pH of 6 is ten times more acidic than a solution with a pH of 7. Pure water is said to be neutral, with a pH of 7. Water with a pH below 7.0 is considered acidic while water with pH greater than 7.0 is considered basic or alkaline.

2.5 *Turbidity*

Turbidity may be due to organic and/or inorganic constituents. Organic particulates may harbour microorganisms. Thus, turbid conditions may increase the possibility for waterborne disease. Nonetheless, inorganic constituents have no notable health effects. The series of turbidity-induced changes that can occur in a water body may change the composition of an aquatic community. First, turbidity due to a large volume of suspended sediment will reduce light penetration, thereby suppressing photosynthetic activity of phytoplankton, algae, and macrophytes, especially those farther from the surface. If turbidity is largely due to algae, light will not penetrate very far into the water, and primary production will be limited to the uppermost layers of water. Overall, excess turbidity leads to fewer photosynthetic organisms available to serve as food sources for many invertebrates. As a result, overall invertebrate numbers may also decline, which may then lead to a fish population decline.

2.6 TDS (*Total Dissolved Solids*)

The total dissolved solids (TDS) in water consist of inorganic salts and dissolved materials. In natural waters, salts are chemical compounds comprised of anions such as carbonates, chlorides, sulphates, and nitrates (primarily in ground water), and cations such as potassium (K), magnesium (Mg), calcium (Ca) and sodium (Na). In ambient conditions, these compounds are present in proportions that create a balanced solution. If there are additional inputs of dissolved solids to the system, the balance is altered and detrimental effects may be seen. Inputs include both natural and anthropogenic source.

2.7 Secchi Disk Transparency

Secchi disk transparency refers to the depth to which the black and white Secchi disk can be seen in the lake water. Water clarity, as determined by a Secchi disk, is affected by two primary factors: algae and suspended particulate matter. Particulates (soil or dead leaves) may be introduced into the water by either runoff or sediments already on the bottom of the lake. Erosion from construction sites, agricultural lands, and riverbanks all lead to increased sediment runoff. Bottom sediments may be resuspended by bottom-feeding fish such as carp, or by motorboats or strong winds in shallow lakes.

b. Chemical Tests

2.8 BOD (Biological Oxygen Demand)

BOD is a measure of organic pollution to both waste and surface water. High BOD is an indication of poor water quality. For this tree plantation project, any discharge of waste into the waterways would affect the water quality and thus users downstream.

2.9 Dissolved Oxygen (D.O.)

D.O. is the dissolved gaseous form of oxygen essential for aquatic life. A low DO (less than 2mg/l) would indicate poor water quality and thus would have difficulty in sustaining much sensitive aquatic life. It is essential for respiration of fish and other aquatic organisms. D.O. enters water by diffusion from the atmosphere and as a by- product of photosynthesis by algae and plants. The concentration of D.O. in epilimnetic waters continually equilibrates with the concentration of atmospheric oxygen to maintain 100% D.O. saturation. Excessive algae growth can over-saturate (greater than 100% saturation) the water with D.O. when the rate of photosynthesis is greater than the rate of oxygen diffusion to the atmosphere. Hypolimnetic D.O. concentration is typically low as there is no mechanism to replace oxygen that is consumed by respiration and decomposition. Fish need at least 3-5 mg/L of D.O. to survive.

2.10 Conductivity

Conductivity is a numerical expression of an aqueous solution's capacity to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence and relative concentrations, and on the temperature of the liquid. Solutions of most inorganic acids, bases, and salts are relatively good conductors. In contrast, the conductivity of distilled water is less than 1 μmhos/cm. Conductivity indicates the presence of ions within the water, usually due to in majority, saline water and in part, leaching. It can also indicate industrial discharges. The removal of vegetation and conversion into monoculture may cause run-off to flow out immediate thus decrease recharge during drier period. Hence, saline intrusion may go upstream and this can be indicated by higher conductivity.

2.11 Total Suspended Solids

Total Suspended solids are an indication of the amount of erosion that took place nearby or upstream. This parameter would be the most significant measurement as it would depict the effective and compliance of control measures e.g. riparian reserve along the waterways. The series of sediment-induced changes that can occur in a water body may change the composition of an aquatic community. The settling of suspended solids from turbid waters threatens benthic aquatic communities. Deposited particles may obscure sources of food, habitat, hiding places, and nesting sites. Most aquatic insects will simply drift with the current out of the affected area. Benthic invertebrates that prefer a low-silt substrate, such as mayflies, stoneflies, and caddis flies, may be replaced by silt-loving communities of oligochaetae, pulmonate snails, and chironomid larvae. Increased sediment may impact plant communities. Primary production will decline because of a reduction in light penetration. Sediment may damage plants by abrasion, scouring, and burial. Finally, sediment deposition may encourage species shifts because of a change of substrate. Sediment deposition may also affect the physical characteristics of the stream bed. Sediment accumulation causes stream bed elevation and a decrease in channel capacity. Flooding is more likely after sediment accumulation because the stream can not accommodate the same volume of water. Also, a substrate that is closer to the surface receives more light and supports increased numbers of photosynthetic organisms, such as rooted algae. As a result, recreational use may be threatened because moving parts of boats may become tangled in aquatic plants. Sediment, which is generally negatively charged, attracts positively charged molecules. Some of these molecules (phosphorus, heavy metals, and pesticides) are pollutants. These positively charged pollutants are in equilibrium with the water column and are often released slowly into the water resource

2.12 Nitrate Nitrogen

The growth of macrophytes and phytoplankton is stimulated principally by nutrients such as nitrates. Many bodies of freshwater are currently experiencing influxes of nitrogen and phosphorus from outside sources. The increasing concentration of available phosphorus allows plants to assimilate more nitrogen before the phosphorus is depleted. Thus, if sufficient phosphorus is available, high concentrations of nitrates will lead to phytoplankton (algae) and macrophyte (aquatic plant) production. This is mostly due to the usage of fertilisers.

2.13 Chemical Oxygen Demand (COD)

COD is an indicator of organics in the water, usually used in conjunction with BOD. High organic inputs trigger deoxygenation. If excess organics are introduced to the system, there is potential for complete depletion of dissolved oxygen. Without oxygen, the entire aquatic community is threatened. The only organisms present will be air- breathing insects and anaerobic bacteria. If all oxygen is depleted, aerobic decomposition ceases and further organic breakdown is accomplished anaerobically. Anaerobic microbes obtain energy from oxygen bound to other molecules such as sulphate compounds. Thus, anoxic conditions result in the mobilization of many otherwise insoluble compounds.

In areas of high organics there is frequently evidence of rapid sewage fungus colonization. Sewage fungus appears as slimy or fluffy cotton wool-like growths of micro-organisms which may include filamentous bacteria, fungi, and protozoa such as *Sphaerotilus natans*, *Leptomitus lacteus*, and *Carchesium polypinuym*, respectively. The various effects of the sewage fungus masses include silt and detritus entrapment, the smothering of aquatic macrophytes, and a decrease in water flow velocities. An accumulation of sediment allows a shift in the aquatic system structure as colonization of sewage fungus may break off and float away, causing localized areas of dissolved oxygen demand elsewhere in the water body.

2.14 Ammonia Nitrogen

Ammonia levels in excess of the recommended limits may harm aquatic life. Although the ammonia molecule is a nutrient required for life, excess ammonia may accumulate in the organism and cause alteration of metabolism or increases in body pH. It is an indicator of pollution from the excessive usage of ammonia rich fertilizers.

2.15 Potassium

Potassium is macro nutrient element for plant growth. It can occur naturally in minerals and from soils. High levels in surface water, especially in areas where there are agricultural activities as indicative of introduction of K due to application of fertilizers.

c. Biological Tests

2.16*Plankton*

Plankton is important members of the aquatic food web. The plankton includes phytoplankton or algae (microscopic plants) and zooplankton (tiny shrimp-like animals that eat algae). The phytoplankton is primary producers that convert light energy from the Sun to plant tissue through the process of photosynthesis. This forms the foundation of the aquatic food chain. Small microscopic shrimp-like crustaceans called zooplankton eat the phytoplankton. In turn, the zooplanktons are extremely important food for young fish. The phytoplankton are organized taxonomically largely by colour. Important phyla (groups) include: Cyanobacteria (blue-green algae), Chlorophyta (green algae), Chrysophyta (yellow-brown algae) and Bacillariophyta (diatoms). The cyanobacteria are of particular interest to limnologists and lake users because members of this group are those that often form nuisance blooms and their dominance in lakes may indicate poor water conditions. Some species of cyanobacteria are known to produce toxins.

2.17 Chlorophylls
The plant pigments of algae consist of the chlorophylls (green color) and carotenoids (yellow color). Chlorophyll-a is the most dominant chlorophyll pigment in the green algae (Chlorophyta) but is only one of several pigments in the blue-green algae (Cyanophyta), yellow- brown algae (Chrysophyta), and others. Despite this, chlorophyll-a is often used as a direct estimate of algal biomass although it might underestimate the production of those algae that contain multiple pigments.

2.18 Microbiological tests
Microbiological test is to detect the level of pollutions caused by living thing especially human who live or work in the area especially upstream of the site. These tests are based on coliform bacteria as the indicator organism. The presence of these indicative organisms is evidence that the water has been polluted with faeces of humans or other warm-blooded animals.

3. Physico-Chemical Parameters of Water in Nepal
Water is one of the largest natural resources of Nepal. The major sources of water are glaciers, snow-melt from the Himalayas, rainfall and ground water. Of these, river water is the most significant in terms of potential development. The rivers alone cover about 54 percent of the total water coverage area in the country [39]. There are over 6,000 rivers in Nepal with an estimated total length of some 45,000 kilometers [40]. Water quality assessment programs in Nepal have concerned generally with public health issues and therefore, safe drinking water has been the primary emphasis of these programs while the conservation of river water quality has received little attention in terms of its development. The people in the Kathmandu valley is facing with Sevier scarcity of water and coping with alternative water source of available quality of water. People are much depended on suppliers (KUKL and water vendors) for water quality because water quality Knowledge level of community is very inadequate. Physico chemical parameter study is very important to get exact idea about the quality of water and we can compare results of different physico chemical parameter values with standard values [41]. Though vast numbers of limnological investigations have been carried out in other countries, only a few works have been done in Nepal. Gupta [42] reported the dominance of calcium among cations, low chloride and less than 1µg/l phosphorus from the high altitude lakes of Mount Everest region. Kanchan and Kanchan [43] studied pre and post monsoon limnological characteristics of lakes of Pokhara and Kathmandu valleys. They recorded low alkalinity and conductivity in the lakes of Pokhara valley. McEachern [44] reported 8.4 pH, 0.03 mg/l phosphate and 8.5 mg/l dissolved oxygen in Narayani, a lowland (2000 m) rivers of Nepal.

4. Conclusion
Climate change requires a global framework for international cooperation. Adaptation action is a vital part of this framework. Actions to enable adaptation to climate change pose opportunities to promote sustainable development. Developing countries require resources in order to promote these actions. A successful framework must directly involve assistance for adaptation in developing countries, particularly Small Island developing States and least developed countries, given that they will disproportionately bear the brunt of climate change impacts.

Least Developed country like Nepal is already suffering from the impacts of climate change and are the most vulnerable to future change. A number of developing countries have developed adaptation plans or are in the process of finalizing them. This includes the National Adaptation Programmes of Action of least developed countries. There is now an urgency for developing countries to find ways to implement these plans. Against a backdrop of low human and financial capacity, developing countries lack many of the resources to do this on their own.

Physico chemical parameter study is very important to get exact idea about the quality of water and we can compare results of different physico chemical parameter values with standard values. Highly impure water has various effects on human being, domestic purpose as well as industrial use. Such as human beings get affected/ infected due to presence of different bacteria and heavy metals present in water. It may affect the different body organ and physiological disorder. Hard water is not suitable for domestic use such as washing, bathing, cooking as well as other purpose. Hard water is also not suitable for industrial and agricultural use. It damages the delicate machineries and affects the quality, stability and glossiness of the final product.

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