Climate change: threats on the medicinal plants in Nepal

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Climate change: threats on the medicinal plants in Nepal

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Abstract: Medicinal plants serve a vital role in human survival. Nepal is rich in biodiversity and it is widely known for its medicinal plant richness, which is both unique and internationally wealthy. Studies have shown that there are various consequences of climate change on medicinal plants. We analyzed historical and contemporary research regarding the threats on the medicinal plants in Nepal accessed through different online sources like Research Gate and Google Scholar. The present study revealed that the climate change has a significant influence on life cycles and the distribution of medicinal plant species. It is evident that climate change is having a considerable impact on the quality and productivity of medicinal plants, morphology, secondary metabolite production, availability of medicinal plant species, etc. Compared to other commercial crops, research on medicinal plants in relation to climate change is intermittent and modest. The current paper emphasizes the urgent need to enhance our understanding of the effects of medicinal plants via diverse studies. The study recommends applying different adaptive measures against climatic catastrophes for the conservation and preservation of medicinal plants.

Keywords: Medicinal plants, Climate change, Impacts, Adaptive measures, Conservation

INTRODUCTION

Biodiversity is commonly recognized to be disappearing at an unprecedented level (Pimm et al., 1995). Climate change has gradually come to be regarded as one of the major concerns for humans as well as for all other species on Earth, and for the world's variations in seasonal patterns, weather events, temperature ranges, etc. (Cavaliere, 2009). The earth's climate is warming at an alarming rate, owing primarily to the exponential increase in carbon dioxide and other greenhouse gas emissions (methane, ozone, and so on) into the atmosphere (Malla, 2008). In recent years, Nepal has faced significant climate change consequences, including rapid retreat of glaciers, quick temperature rises

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(> 0.06 °C per year), unpredictable precipitation, huge biodiversity extinction, and an increasing incidence of catastrophic events such as floods and droughts (Karki et al., 2009). Nepal, being a country with high geographical and climatic variations, nature has bestowed the country with an enormous wealth of medicinal plants. Despite accounting for barely 0.1 percent of the world's geographical area, Nepal ranks tenth among Asian nations in terms of floral abundance, with an elevational distribution of 2,331 medicinal plant species (Rokaya et al., 2012; Kathmandu Post, 2017). According to Department of Plant Resources data from 2006, among 700 medicinal plants, 13 are classified in the CITES Appendices, 16 are protected by the Nepal government, and 60 are endangered medicinal plants (Joshi, 2012). Medicinal herbs are an essential part of health care and the majority of people across the globe benefit from them to treat well-being issues and relieve human suffering (Applequist, 2019). Almost all societies have a high level of dependence on medicinal plants (Sharma et al., 2020). According to the World Health Organization (WHO), they provide the primary health care requirements of 60% of the world's population and 80% of residents in most developing countries (Kursalge, 2009). Only 17% of Nepalese city dwellers have access to modern medication, while the rest of the population relies on herbal remedies (CBS, 2007; Uprety et al., 2010; UNEP, 2012). Plants can adjust to minor changes in weather patterns and climatic fluctuations, but if these changes get more severe, their capacity to adapt will be tested, and they simply may resort to coping (Becklin et al., 2016). Climate change is having a substantial influence on the life cycles and vegetation distribution, including wild as well as cultivated medicinal plants (Mishra, 2016). Climate change impacts on medicinal plants include decreases in availability, accessibility, productivity, and, most significantly, species extinction (Applequist, 2020), as well as influences on the phytochemical composition of surviving populations and their pharmaceutical qualities (Gairola, 2010).Some medicinal plants are endemic to areas or ecosystems that are particularly sensitive to climate change, putting them at danger (Neilson et al., 2005). Extreme weather events have affected the ability of harvesters and farmers to cultivate and collect medicinal plant species, impacting medicinal plant production from sowing through harvesting around Europe, such as chamomile in Germany and Poland (Pompe et al., 2008). The Sahel region of Africa was the site of one of the most severe droughts of the 20th century. The Sahel is home to a number of medicinal plants, including *Hibiscus sabdariffa, Commiphora africana, Boswellia spp., Adansonia digitata, Moringa oleifera,* and various *Aloe spp.* (Held et al., 2005). Climate change's harmful effects on medicinal plants will grow considerably more powerful and frequent in the future, especially if ecologically detrimental human activities continue unabated (Walther et al., 2002). Nepal, which is one of the climate change vulnerable country, no major research has been carried out on threats of climate change on medicinal plants (Harish et al., 2012). This study was conducted to shed light on the threats of climate change to medicinal plants.

METHODOLOGY

The review is devoted to examining the implications of climate change on medicinal plants in Nepal. A website-based search strategy was utilized to identify literature documents pertinent to the review. Research Gate and Google scholar were used to access all the documents published until November 2021, required for the study.

RESULTS AND DISCUSSION

Change in Quality and Productivity of medicinal plants: With global temperature change, precipitation variations and CO_2 concentration, as well as changes in specific climatic resources, diverse species have altered dynamics and balance and affected their production (Rivaes et al., 2014).

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Detrimental effects of climate change have also been seen in the quality and quantity of medicinal plants produced. Endangered plant species are considered more vulnerable to climate change and may face a high risk of extinction due to their confined geographic distribution (Kunwar et al., 2014). Even though variations in chemical composition in food plants may be more significant to human health than is widely recognized, the entire objective of medicinal plant ingestion or other uses is to gain health advantages from their bioactivities (Applequist et al., 2020). Many researchers have demonstrated that the synthesis and accumulation of beneficial components in herbal medicines has a strong association with their habitat's distinct climatic environment (Mudge et al., 2016; Yang et al., 2019; Kfoury et al., 2019). The ‘precipitation of seasonality' was determined to be suitable for the majority of medicinal plants, with a range of 66–120 mm. Geographically, the mid-elevation range of 1800–4200 m was found to be more preferable for all MAPs, increasing the probability of existence for *Acer spicatum, Neopicrorhiza scrophulariflora, Nardostachys jatamansi*, and decreasing the probability of existence for *Valeriana jatamansi, Paris polyphylla*, and neutral or minimum change for *Dactylorhiza hatagirea* at the same altitudinal range in the future. (Rana et al., 2020). When looking at overall *Morchella esculenta* output from 2005 to 2014, it was declining and rainfall was also declining from 1980 to 2018, respectively in Humla district. Likewise, when the annual output of *Delphinium himalayai* was examined from 2004 to 2014, it was discovered that the production of *Delphinium himalayai* dropped as the temperature rose. The rise in temperature appears to have impacted the growth and productivity of *Delphinium himalayai*. When yearly rainfall from 1980 to 2018 and an average temperature of 28 years, i.e., from 1990 to 2018, were compared to *Nardostachy grandiflora*'s annual production from 2004 to 2014, it was discovered that the production of *Nardostachy grandiflora* increased as the temperature increased. Likewise, with the rise in temperatures, the production of *Swertia chirayita* has also increased in the Humla district as a positive impact of climate change (Shahi et al., 2020). Rainfalls at inconvenient times, along with temperature rises and falls at inconvenient times, have a negative impact on the production of therapeutic plants. It is crucial to have knowledge of the effects of climate change on medicinal herb cultivation (Shahi et al., 2020). One example of a potential organism-level investigation is the predicted range increase of the Himalayan endemic Chinese caterpillars (*Ophiocordyceps sinensis*) (Shrestha et al., 2014).Different predictions are based on the current link between temperature and physiology between the fungus, and hence it is acceptable to expect changes at organism levels in this species that can be individually assessed. Physiological changes at the organism level, such as temperature-driven responses, may be assumed in studies that track and anticipate changes in alpine tree line dynamics (Bhattacharjee et al., 2017). Poor people used to utilize medical plants to cure common ailments and avoid hospitalization, but today, the same sorts of illnesses do not react to the same medicinal herbs (Charmarka and Mijar 2009). Plant phenology, growth behavior, and range have been altered as a result of climate change, putting species' production, product quality, and even existence in danger (Sala 2000; Kunwar et al., 2010). The medicinal and aromatic herbs, chiraito, jatamasi, lothsalla, and panchaunle, which are subsistence products of poor and marginalized people settling near forests, are all suffering from a decline in quality, quantity, diversity, and distribution in the Sacred Himalayan Landscape of Nepal (MoE, 2010).

Secondary metabolite production in medicinal plants: Temperature stress has been shown in certain studies to influence the secondary metabolites and other chemicals produced by plants, which are generally the basis for their therapeutic action (Schar et al., 2004). It was also observed that such alterations may be good or negative, but it appears that the consequences would be detrimental since secondary metabolites are generated in greater numbers under stressful conditions (Das et al., 2016). Secondary metabolite production may increase in general when plants are stressed because growth is

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frequently hindered more than photosynthesis, and the carbon fixed that is not assigned to growth is instead allocated to secondary metabolites (Gairola, 2010). The most frequent defense strategy used

by plants in response to high temperatures is the production and accumulation of suitable solutes. Amino acids, amines, c-amino-N-butyric acid, antioxidants and total sugars (fructose, sucrose, proline, etc.) are among the compounds (Wani and Gosal 2010; Wani et al., 2013; Harsh et al., 2016). Some researchers claim that secondary metabolites rise in response to higher temperatures (Litvak et al., 2002), while others claim the opposite (Snow et al., 2003).

Decrease availability and threat to medicinal plant species: According to a recent study, over 600 plant species have become extinct in the last 250 years (Humphreys et al., 2019). Asia and the Pacific had the largest number of endangered species in 2008, with severe issues in South-East Asia and an estimate that 25,000 species of plant may become extinct (UNEP, 2010). The average global temperature has increased by 16.94°C over the last century and is expected to climb by another 17.5°C during the next century (Sapkota and Rijal, 2016). Even these small variations in the temperature over a century can lead to huge hazardous situations for many species of medicinal plants. Many plant species are, or will soon be, threatened with extinction on a local or global scale. Nepal is located in the Hindu-Kush Himalayan area and, according to the Intergovernmental Panel on Climatic Change, the Himalayas will likely experience some of the most dramatic climate changes with temperature rises of 5-6°C and precipitation increases of 20-30%, which will be much worse for the rare flora that only thrives in these highlands (Uprety, 2021). This may directly result in the decline in availability and extinction of a population of highly valued medicinal plants.

According to CITIES, *Saussurea lappa*, having high ethno-medicinal value and used for the treatment of diarrhea, tenesmus, vomiting, inflammation, dyspepsia, and over 43 other diseases (Zahara et al. 2015), is a species threatened with extinction in Nepal. The availability of *Dactylorhizea hatagirea* is declining due to haphazard collection, limitation in propagation (Magar et al., 2020), and on top of that, climate change is adding threats to this type of endangered life form (Awale, 2019). Recent research indicated substantial habitat losses in Nepal, with a 71–81% decline in suitable sites for *Dactylorhizea hatagirea* by 2050 and a 95–98% reduction by 2070 in the worst case scenario. By 2070, the most optimistic scenario predicts a decrease of 65–85% (Shrestha et al., 2021). The Manaslu Conservation Area, Annapurna Conservation Area, and Lantang National Park are the home lands of Himalayan medicinal plants, i.e., *Fritillaria cirrhosa* and *Lilium nepalense*, which are expanding toward the north-west as the climatic conditions are harsh on low land and clustered forms may be developed which will eventually support their extinction by 2050 in hilly and lower mountainous regions (Rana et al., 2017). In higher elevations of Nepal, *Terminalia bellirica, Abies spectabilis, Acorus calamus, Aegle marmelos, Bergenia ciliata, Cissampelos pareira, Paris polyphylla, Ophiocordyceps sinensis, Zanthoxylum armatum,* and *Ziziphus mauritiana* are endangered (Kunwar et al., 2014). The species *Rheum australe*, which grows well in cold dry regions with rainfall, is severely damaged by irregular and untimely rainfall as well as high temperatures and thought that this species has become extinct in Humla district (Shahi et al., 2020).

Shift in morphology and phenology of medicinal plants: Climate change may have an immediate impact on plant fitness (Galen and Stanton, 1991), as well as on plant reproductive success and diversity interactions through effects on blooming phenology (Hughes, 2000). Plant life cycles are tied to seasonal signals, thus changes in their timing provide some of the most compelling evidence that global climate change is having an impact on species and ecosystems (Cleland, 2007). As global warming continues, spring and the growing year will be affected (Harish et al., 2012). Early flowering

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might be detrimental if the location is prone to cold periods late in the spring season. If a cold period came a few days or weeks after early flowering began, those early buds or fruits froze, potentially destroying or impairing the output of certain commercially valuable plants (Zobayed et al., 2005). Adaptive characteristics of trees, such as small, stunted, and multi-stemmed individuals, were found at higher elevations in response to climate change. At higher elevations, Abies trees with a shorter height and a lower canopy were shown to be more resistant to climate change (Billings, 1974). Adaptive characteristics included clonal growth and strong coppicing qualities, as seen in *Rhododendron anthopogon*, and peeling bark in *Rhododendron campanulatum*. *Salix sikkimensis* showed early leaf emergence, but *Rhododendron arboretum, Larix himalaica and Rhododendron campanulatum* were seen to bloom early (Kunwar et al., 2014). *Salix sikkimensis* showed early leaf emergence, while *Larix himalaica* showed early flower initiation in the Sacred Himalayan Landscape of Nepal (Kunwar 2011). The impact of climate change on plant phenology is difficult to infer because it is unique to species and microclimates. Shifting phenologies and distributions may appear insignificant at first glance, yet they have the ability to pose serious threats to species' existence and livelihood (Cavaliere, 2009).

Shifting ranges of medicinal plants: Climate changes also lead to the migration of plants into new ranges. According to studies and computer modeling tools, plant ranges have begun to migrate towards the poles and/or higher altitudes in an effort to "reclaim" suitable growth zones (Walther, 2002). Habitat loss and climate-related migration problems may cause many endemic species to go extinct (Keutgen et al., 1997) as these plants move upward until they can no longer find higher places to live. The distribution records of species from lower altitudes in previous days and succeeding records from progressively higher altitudes corroborated with distribution upshifts in the case study of the Himalayan area. *Larix himalaica* and *Pinus roxburghii* upshifted 4 m each year, while *Rhododendron arboreum* upshifted 0.88 m per year. Upshift of *Abies spectabilis* of 2.5 meters per year in Langtang, Central Nepal, confirmed previous observations (Gaire and Bhuju, 2010; Kunwar, 2011) while vegetation upshift in response to climate change generally varies between 1-2 meters per year (Camarero et al., 2006).

Coexistence: Species which rely on one another can, in such instances, both be pushed to extinction if they no longer co-occur in space and time. Pest and invasive species can spread to new areas, placing additional strain on sensitive populations of medicinal plants. Conservative plant species that have certain habitat needs or have long generation periods are more likely to be endangered (Benning et al., 2002).

CONCLUSION

Climate change may not offer the largest threat to medicinal plants, but in decades to come it may become a much bigger one. But the impacts on medicinal plants due to climate have not been thoroughly explored. The probable extinction of medicinal plant species would undoubtedly have a substantial influence on the lives of many vulnerable communities worldwide as many underprivileged people depend not just for their primary health care but also as a major source of revenue. With the current scenario, climatic changes might make the herbal community more stressed and may have an impact on the consumers, harvesters, and producers of medicinal plants. If action is not taken promptly, this might lead to greater human suffering and unavoidable fatalities. Although the future consequences of climate change are mostly unknown, existing data shows that these phenomena are having an impact that certain possible risks are worth discussing. These plants are in danger of being lost for good unless a global move is made. Further research must be focused in the affected areas for developing conservation strategies. Farmers in Nepal can try to adapt to the challenges posed by the

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climate catastrophe by employing innovative techniques as well as using traditional indigenous knowledge. Threatened wild medicinal plants can be preserved by its domestication or gene bank establishment.

DECLARATION OF CONFLICT OF INTEREST

No conflict of interest to declare.

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