CLIMATE IMPACTS 1(1), January - March, 2015

ISSN 2394–8558 EISSN 2394–8566

Climate Change

Climate Change and Its Impact on Medicinal and Aromatic Plants: A review

Pabitra Aryal

Central Department of Environmental Science, TU, Kirtipur, Nepal

Publication History
Received: 23 November 2014
Accepted: 24 December 2014
Published: 1 January 2015

Citation
Pabitra Aryal. Climate Change and Its Impact on Medicinal and Aromatic Plants: A review. *Climate Change*, 2015, 1(1), 49-53

ABSTRACT

Climate change has become increasingly recognized as one of the greatest challenges to humankind and all other life on Earth. The world is becoming hotter day by day, since the earth's temperature has risen up to 0.74°C and is about to increase from 1.8° C to 4° C by 2100. Though being small country Nepal experiences a wide range of climate varying from the sub-tropical to the alpine type. The status of medicinal and aromatic plants is the important issue in current period for the study of environment and climate change. In recent years the impact of climate change is very high and currently we are observing that some species of plants are not in their original habitat and some are sifting to higher range for survival. Some of the medicinal plants show change in chemical properties in their composition. The most threatening fact is that many species are lost from the earth. In Nepal, approximately 14% of plant species are used as NTFPs. Medicinal plant trade is a blooming business worldwide and the third world countries including Nepal. Climate change is affecting medicinal and aromatic plants around the world and could ultimately lead to losses of some key species in Nepal as well Species endemic to regions and causing plants to migrate into new ranges. The effects of climate change on medicinal plants, in particular, has not been well-studied and is not fully understood. As the situation unfolds, climate change may become a more pressing issue for the herbal community, potentially affecting users, harvesters, and manufacturers of MAP species. So it is very necessary to study on MAP's and its potential and ecological status and in details. The conclusion and outcomes of the study will guide to the steps to be taken to come out from this disastrous issues in near future.

1. INTRODUCTION

Climate change has become increasingly recognized as one of the greatest challenges to humankind and all other life on Earth. Worldwide changes in seasonal patterns, weather events, temperature ranges, and other related phenomena have all been reported and attributed to global climate change. Numerous experts in a wide range of scientific disciplines have warned that the negative impacts of climate change will become much more intense and frequent in the future particularly if environmentally destructive human activities continue unabated.

The world is becoming hotter day by day, since the earth's temperature has risen up to 0.74°C and is about to increase from 1.8° C to 4° C by 2100 (Anonymous, 2007). This change in climate is occurring due to increased urbanization, fuel burning and high emission rate of carbon dioxide, which traps into the atmosphere and cause global warming (Anonymous, 2010).Climate change is a disastrous issue which is impacting the world over a large scale, while the most vulnerable to climate change are the underdeveloped regions of the world, significantly the South Asian states for example Nepal, Bhutan, Bangladesh etc. The major impacts of climate change in South Asia will include the melting of glaciers in Himalayas and consequent increase in flooding, a pressure would build up over the natural resources and a resulting stress over the environment, disease outbreak, impacts on soil fertility, which will end up in erosion and reduced crop growth, this will correspondingly impact the economy and would be a cause of poverty. This all will impede the achievement of environmental sustainability by accelerating child mortality, disrupting the social system and damaging the vegetation. For example, the climate change activity has caused a loss of around $3.57 billion over the past 18 years in Pakistan. This is alarming, since this would cause the risks of sea level rise, glacial retreat, floods, temperature extremes and intensified droughts (Khan, 2009).

Nepal is situated in the central part of Himalayas between 26º22' and 30º27'N latitudes and 80º04' and 88º12'E longitudes covering an area of 147,181 sq. km (Central Bureau of Statistic (CBS), 2007). The country is around 850 km long (east-west) and 200 km (north-south) wide. Altitude varies from 67 m to 8,848 m above the mean sea level (m.s.l.). Though being small country Nepal experiences a wide range of climate varying from the sub-tropical to the alpine type. The climatic conditions of Nepal are summarized below:

Ecological belt	Climate	Average precipitation	Average Temperature
Mountain	Arctic / Alpine	Snow 1500mm-2000mm	< 3 ºC -10 ºC
Hill	Cool/Warm Temperate	275mm-2300mm	10 ºC -20 ºC
Terai	Sub-tropical	1100mm-3000mm	20 ºC -25 ºC

(Source WECS, 2005)

Climatic changes and its impacts on the vegetation are a natural phenomenon that has been occurring in the Earth's five billion-year-old history (Anonymous, 2007). In the past few decades, global climate change has had a significant impact on the high mountain environment: snow, glaciers and permafrost are especially sensitive to changes in atmospheric conditions because of their proximity there arose problems in natural habitat of plants. These effects had developed adverse effect on medicinal plants as well (Anonymous, 2007). In these days the climatic condition of Nepal also vastly changed and it has direct impact on natural vegetation, Himalayan, tropical and subtropical region (Shrestha *et al.*, 2001). The major cause of climatic imbalance is noted as deforestation and uses of fuel which emits carbonic components and it leads to rise in temperatures. The forest and green vegetation is degraded due to high population and imbalance use of natural resources. Climate change had created change in chemical properties of some medicinal plants as the time of growth and ripening has been changed as from past (Zobayed SMA *et al.,* 2005). Most of the medicinal plants of Nepal are in un-identical form and through study of them are not carried out even we do not have proper records of those as well (Malla and Shakya, 1968). So we cannot say in exact what is the status of those plants in the context of Nepal.

2. RESULT

In Nepal, approximately 14% of plant species are used as NTFPs (Rawal, 1998). Among all categories of NTFPs Medicinal and Aromatic plants (MAPs) play vital role in Nepalese livelihood, health, and socio-economic prospects. Basnet (2001) has reported 61 species of NTFPs from the Terai area, all having medicinal value. Some of these NTFP species: Bojho (*Acorus calamus*), Kurilo (*Asparagus racemosus*), Harro (*Terminaliachebula*), Barro (*Terminalia bellirica*), Amala (*Phyllanthus emblica*), Bet (*Calamus tenuis*), Sal

(*Shorea robusta*), Bhyakur (*Dioscorea deltoida*), and Sarpagandha (*Rauvolfiaserpentina*), etc., from the tropical zone are highly exploited due to deforestation, overgrazing, forest fire, shifting cultivation and massive harvesting. It has been estimated that around 119 pure chemical substances extracted from some 90 species of higher plants are used in medicines throughout the world. Over 21,000 plant names that have medicinal uses are reported by WHO (1992). In Nepal, more than 1,600 species of wild plants are used in traditional medicinal practice and majority of which await proper documentation (Shrestha *et al.*, 2001). In Nepal Pandey (1968) accounted 70 species from Terai, Siwalik, Mahabharat and Himalaya. Malla and Shakya (1968) listed 287 species. Medicinal plants of Nepal (1968) illustrated 393 species along with their therapeutic uses. Manandhar (1980) illustrated 37 species. Tiwari and Joshi (1990) mentioned 300 species, which are commonly used in Ayurvedic preparation with their indications (Gachhadar P., 2006).

Medicinal plant trade is a blooming business worldwide and the third world countries including Nepal are the main supplier of resources harvested mainly from wild to meet the global demand for the drug discovery. The trade of medicinal and aromatic plants from Nepal is roughly estimated at 10,000-15,000 tons annually representing more than 95% of the quantity harvested from wild worth equivalent to US $ 8.6 million (Edwards, 1996).

Climate change is affecting medicinal and aromatic plants around the world and could ultimately lead to losses of some key species in Nepal as well Species endemic to regions or ecosystems that are especially vulnerable to climate change. Climate change has led to shifts in seasonal timing and/or ranges for many plants, which could ultimately endanger some wild medicinal populations. Extreme weather events, meanwhile, have begun to impact the various medicinal plants. Impending climate change is just one factor that could contribute to the loss of MAPs Plants have a lot of time-sensitive relationships, and many will be disrupted in the future from climate change Changes in climate are also causing plants to migrate into new ranges. The range shifts of wild plants from climate change could ultimately jeopardize the survival of some species some types of extreme weather events have been striking more frequently and with greater force throughout the world and it has direct effect on medicinal plants growth. Climate change has been affecting vegetation patterns such as phenology (the timing of life cycle events in plants and animals, especially in relation to climate) and distribution. Phonological variation between plant species in the same ecosystem can reduce competition for pollinators and other resources. Climate change could affect the chemical composition and, ultimately, the survival of some MAPs. Capturing genetic diversity becomes increasingly important since it is possible that plants will lose genetic diversity in response to the changing environment for survival. Himalaya Mountains are likely to experience some of the most dramatic climate changes, with temperatures increasing by as much as 40 to 42 degrees and precipitation increasing by as much as 30 percent over time (Salick J, 2009). Such climate changes would have a severe impact on the alpine Himalayan plants. Compared to the Himalayas, the percentage of alpine plants used medicinally in the Alps is much lower, at approximately 10%. Most of the plants from mountain ecology can easily be cultivated by ex situ. Many of alpine plants could potentially invade (or escape to) higher elevations as a result of global warming and that the plants' risk of extinction under predicted scenarios appears to be relatively low.

3. REVIEW AND DISCUSSION

In these days the climatic condition of Nepal also vastly changed and it has direct impact on natural vegetation, Himalayan, tropical and subtropical region. The major cause of climatic imbalance is noted as deforestation and uses of fuel which emits carbonic components and it leads to rise in temperatures. The forest and green vegetation is degraded due to high population and imbalance use of natural resources.

Impact of climate change in green vegetation of Nepal

Nepal is among the highly vulnerable country to climate change impacts. The technique of GIS mapping plays an important role while determining the changes in land cover due to deforestation or forest degradation. One such study was carried out in Chitwan District in Nepal. One of the major forests of the region, the Terai Shorea robusta forest showed a loss of 23% between 1976 and 1989. Besides this, overall there was a loss of 15% forest covers between the year 1976 and 2001 (Panta *et al.*, 2008).This type of degradation of natural forest has direct influence on medicinal plants and their growing environment. This study tries to highlight the impacts of climate change, on cover value of forest and medical plants together.

Effect of climate change on medicinal plants

Like all living members of the biosphere, medicinal and aromatic plants (MAPs) are not immune to the effects of climate change. Climate change is causing noticeable effects on the life cycles and distributions of the world's vegetation, including wild MAPs. Some MAPs are endemic to geographic regions or ecosystems particularly vulnerable to climate change, which could put them at risk. Concerns regarding the survival and genetic integrity of some MAPs in the face of such challenges are increasingly being discussed within various forums. In Nepal, more than 1,600 species of wild plants are used in traditional medicinal practice (Shrestha *et al.*,

2001). The trade of medicinal and aromatic plants from Nepal is roughly estimated at 10,000-15,000 tons annually (Edwards, 1996). The possible effects on MAPs due to climate change may be particularly significant due to their value within traditional systems of medicine and as economically useful plants. The future effects of climate change are largely uncertain, but current evidence suggests that these phenomena are having an impact on MAPs and that there are some potential threats worthy of concern and discussion.

Medicinal and Aromatic Plants in Higher Mountains

Higher mountains of Nepal above 4,400 meter altitude represent the arctic type of climate. Warming is occurring more rapidly in the Arctic than anywhere else in the world (IPCC, 2007). Changes in snow patterns, ice cover, and temperatures are already affecting the distribution of some Arctic vegetation. Some experts postulate that climate change could affect the chemical composition and, ultimately, the survival of some MAPs in Arctic regions. The changing temperatures and wind patterns associated with climate change are affecting precipitation factors and giving some trees and shrubs the ability to grow taller and in more open areas. These taller plants then become barriers to snow, fencing it in and changing the surrounding biodiversity. Some studies have demonstrated that temperature stress can affect the secondary metabolites and other compounds that plants produce, which are usually the basis for their medicinal activity (Zobayed SMA *et al.,* 2005). But few studies have been conducted in situ (in natural settings) or ex situ (in a controlled non-natural setting) to mimic conditions of global warming gives different results. Medicinal effectiveness of some Arctic plants could possibly be affected by climate change. Such changes could either be positive or negative, although it seems more likely that the effects would be negative since secondary metabolites are produced in larger quantities under stressed conditions and for Arctic plants warmer temperatures would likely alleviate environmental stress (NGB, 2006).

Medicinal and Aromatic Plants in Lower Mountains

Lower mountains of Nepal with altitude 4000 meter to 4400 meter represent alpine type of climate. Plants growing in alpine environments also are particularly impacted by climate change. After Polar Regions, alpine areas are changing faster than any other areas on Earth. Plant species in alpine environments have begun to gradually climb higher up mountain summits—a phenomenon correlated with warming temperatures (Yoon CK, 1994). These plants migrate upward until there are no higher areas to inhabit, at which point they may be faced with extinction. The upward migration of plant species can lead to increased competition for space and resources, causing further stress among alpine plant populations (Yoon CK, 1994 and Salick, 2009).

Predominantly medicinal plants accounted for 62% of all plant species in the alpine Himalayan (Salick, 2009). Further, although overall species richness was found to decline with elevation from the lowest summits to the highest, the proportion of useful plants stayed approximately constant. This high percentage of useful plants confirms the importance of the Himalayas reflects the dangers posed by potential plant losses from climate change. Himalayas are likely to experience some of the most drastic climate changes in the world outside of Polar Regions, with temperature increases of 5-6°C and precipitation increases of 20.30 % (Salick, 2009). Such figures indicate that climate change is likely to have equal or greater effects on Himalayan alpine vegetation than on vegetation found elsewhere. Research shows many alpine plant species have proven difficult or impossible to cultivate, the conditions that they need to grow are just so unique and somewhat unfathomable so there is no option to protect their species. Many of alpine plants could potentially invade (or escape to) higher elevations as a result of global warming and that the plants' risk of extinction under predicted scenarios appears to be relatively low (Grabherr G. 2009).

Medicinal and Aromatic Plants in Other Threatened Regions

Although Mountain areas are experiencing some of the most rapid changes from global warming, other ecosystems of the world are also considered particularly threatened by the ongoing effects of climate change. Among these ecosystems are islands and rainforests. Islands are considered especially at risk from rising ocean levels, in addition to changing temperatures and weather patterns. According to the 2007 IPCC report, global average sea levels rose at an average rate of about 3.1 mm per year from 1993 to 2003.Climate change is expected to accelerate this process through the melting of glaciers and polar ice caps, which adds water into the oceans. The world's oceans also absorb excess heat from the atmosphere, and as water warms it expands in volume (a process known as thermal expansion), which will similarly contribute to global sea level rise. In 2006, a team of scientists, using computer models and climate change scenarios proffered by IPCC, calculated that up to 65% of some islands in the Northwestern Hawaiian Islands could be submerged by the year 2100 (Owen J.,2006). Despite these threats, experts have indicated that island MAPs may not be significantly affected by conditions related to climate change. Many of the plants used by island communities are common species that are widespread and highly adaptable. Very few plants that are used as medicines are actually rare or endangered and most are in fact so common that they are often taken as weeds. other medicinal plant species of these area grow

relatively fast, have high reproduction rates, and are typically resistant to salt water and wind, making them more resilient to some of the predicted effects of global climate change.

From the all the observed data it shows the MAPs are in threaten position and we need to make approach to protect their habitat.

4. CONCLUSION

The effects of climate change are apparent within ecosystems around the world, including medicinal and aromatic plant populations. MAPs in Arctic and alpine areas face challenges associated with their rapidly changing environments, and some researchers have raised concerns regarding the possible losses of local plant populations and genetic diversity in those areas. Shifting phenologies and distributions of plants have been recorded worldwide, and these factors could ultimately endanger wild MAP species by disrupting synchronized phenologies of interdependent species, exposing some early-blooming MAP species to the dangers of late cold spells, allowing invasive to enter MAP species' habitats and compete for resources, and initiating migratory challenges, among other threats. Extreme weather events already impact the availability and supply of MAPs on the global market, and projected future increases in extreme weather are likely to negatively affect MAP yields even further.

Climate change may not currently represent the biggest threat to MAPs, but it has the potential to become a much greater threat in future decades. The potential loss of MAP species from effects of climate change is likely to have major ramifications on the livelihoods of large numbers of vulnerable populations across the world. Further, the problems associated with climate change are likely to be much more difficult to combat than other threats to MAPs.

In case of Nepal to combat against climate change it is necessary to protect natural ecology and enhanced the optimum uses of natural resources. Laws can be passed to stop deforestation and over-collection, and in some cases such laws might have achieved immediate results. The problems posed by warming temperatures, disrupted seasonal events, extreme weather, and other effects of climate change, on the other hand, cannot be so quickly and easily resolved. The effects of climate change on medicinal plants, in particular, has not been well-studied and is not fully understood. As the situation unfolds, climate change may become a more pressing issue for the herbal community, potentially affecting users, harvesters, and manufacturers of MAP species. So it is very necessary to study on MAP's and its potential and ecological status and in details. The conclusion and outcomes of the study will guide to the steps to be taken to come out from this disastrous issues in near future.

REFERENCE

1. Anonymous. 2007. IPCC (Intergovernmental Panel on Climate Change). Climate change 2007: the physical science basis. Geneva, Switzerland.
2. Anonymous. 2010. District Gazetteer of Chakwal. 2010. Divisional Forest Office, Rawalpindi.
3. Basnet, K. 2001. Terai Arc landscape asessment: Biodiversity component. A report submitted to WWF, Nepal.
4. CBS, 2007. Statistical year book Nepal. Central Bureau of Statistics, National Planning Commission, Kathmandu, Nepal.
5. Edwards, D.M. 1996. Non-timber forest products from Nepal. Aspects of the trade in Medicinal and aromatic plants. FORSEC Monographs. Forest research and survey center, Kathmandu, Nepal.
6. Gachhadar P., 2006. "*Indigenous knowledge and practices on medicinal plants among Tharu community in Eastern Nepal*".
7. Grabherr G. 2009. Ethnobotanical and climate change perspectives on biodiversity in the high ranges of the Alps. [In press]
8. Intergovernmental Panel on Climate Change. Climate Change 2007: Synthesis Report. November 2007. Available at:http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4 _syr.pdf.
9. Khan, K. 2009. Climate Change Cost Pakistan $3.5 Billion in 18 Years. freebird.instablogs.com. Date of retrieval: 15th April 15, 2010.
10. Owen J. 2006. Global warming may swamp Hawaiian wildlife, study warns. *National Geographic News*. June 5, 2006. Available at: http://news.nationalgeographic.com/news/2006/06/060605-hawaii.html.
11. Panta, M., K. Kim and C. Joshi. 2008. Temporal mapping of deforestation and forest degradation in Nepal: Applications to forest conservation. *Forest Ecology and Management,* 256: 1587-1595.
12. Protecting medicinal plants from climate change [press release]. Sweden: Nordic Gene Bank; September 8, 2006
13. Rawal, R.B. 1997. Status of commercialization of medicinal and aromatic plants of Nepal. In Karki M. *et al.* (Eds.) The role of bamboo, Rattan and medicinal plants in mountain development. INBAR Technical Report No. 15. pp. 174-188.
14. Salick J, Zhendong F, Byg A. 2009 Eastern Himalayan alpine plant ecology, Tibetan ethnobotany, and climate change. [In press]
15. Shrestha, K.K., N.N. Tiwari and S.K. Ghimire. 2001. MAPDON – Medicinal and Aromatic Plant Database of Nepal. In Proceedings of Nepal-Japan Joint Symposium 2000. Department of Plant Resources, Thapathali, Kathmandu, Nepal. 53-74.
16. WECS 2005. National Water Plan, His Majesty's Government of Nepal, Water and Energy Commission Secretariat (WECS), Kathmandu
17. Yoon CK. Warming moves plants up peaks, threatening extinction. *New York Times*. June 21, 1994:C4.
18. Zobayed SMA, Afreen F, Kozai T. 2005. Temperature stress can alter the photosynthetic efficiency and secondary metabolite concentrations in St. John's wort. *Plant Physiology and Biochemistry*. 2005; 43:977-984.