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Botanical Contributions of Nepalese Scientists to Climate Change in Nepal: A Review

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Abstract

Climate Change has been a recent consequence of global warming among other detrimental anthropogenic activities. It concerns studies among various disciplines of social and natural science. The objective of this paper is to document the studies on Climate Change by Nepalese Scientists in field of Botany. Research and review papers on climate change studies in various fields of Botany were acquired from Google Scholar. Altogether 32 papers/studies were obtained till 2024. They are from different fields of Botany such as forestry, agriculture, ethnobotany, environment, biological invasion, dendrochronology, tree line shift, food and water security, disaster risks, etc. The data collected were analyzed to present them conveniently to the general readers. There was a short review of the discourses from the contributor Botanists from Nepal. There was 31% study during 2010-2015, 47% during 2015-2020 and 22% during 2020-2024. This study will be fruitful for finding who is who in Botany and finding the gaps in climate change studies from Nepal with perspectives of plant science.

Keywords: Anthropogenic Climate Change, Carbon emissions, Global Warming, Greenhouse Effect,

Introduction

The weather events are the day-to-day changes in rainfall, temperature, snowfall, wind speed, cloud cover, and humidity that occur in a particular location. Weather refers to the specific condition of the atmosphere at a particular place and time (Moore et al., 2009) but the climate is a statistical characterization of the weather, averaged over many years; it is usually represented in terms of means, variability, and extremes of the various weather elements. When these weather events remain constant for more than two/three decades, it becomes the climate for that region. The changes in the prevalent climate at any time for this duration is called climate change. History of climate change was frequent in Earth time to time. It is clear that climatic variation has regularly played a part in historical development particularly to Europe since ad 211 (Enfield, 2003).

Solar output or the solar radiation to Earth is not always constant. It fluctuates frequently and becomes the cause of climate change. Sometimes collision of tectonic plates under the Earth crust brings changes in surface configuration of the Earth with the climate change. In history of the evolution, the orbiting of the Earth around the sun also varies and it becomes the cause of climate change. Tilting of the Earth's axis varies with time and cause the change in the climate. Volcanic eruption carries the molten rocks and metals on Earth surface in the form of magma. As much as 41 to 64% of pre-anthropogenic (pre-1850) decadal-scale temperature variations was due to changes in solar irradiance and volcanism (Crowley, 2000). The cloud it develops block the solar radiation and may cause fall of temperature and the heat brought by magma may increase the temperature as well. Changes in ocean variability with time and space cause climate change (Reid et al., 2009). Human influence has the great impact on the recent climate change. The 21st-century global warming projection far exceeds the natural variability of the past 1000 years and is greater than the best estimate of global temperature change for the last interglacial (Crowley, 2000).

Anthropogenic aerosol forcing most likely masked some global greenhouse warming over the 20th century, especially since the accelerated increase in sulphate aerosol emissions starting around 1950 (Hegerl, 2019). The urban heat island is the elevation of air temperature within cities. Paved ground surfaces transport more solar heat downwards than soil; this heat is then available for release overnight (Parker, 2010). People are using firewood as well as different fossil fuels as source of energy for household consumption, running vehicles and running industries. As a result, different harmful gases like H_2S, SO_2, No_x, CO, CO_2, CH_4, etc. are produced in huge amount. They are accumulated on the Earth surface making a thick blanket that traps the infrared rays from the sun and prevent them to return back to the atmosphere and thus become the cause of the greenhouse effect or global warming. Despite a few unexplained observations and inconsistencies, the huge majority of the world's scientists now accept that the increase in Planet Earth's temperature, or global warming, is real, and will have a disastrous impact on our ecosystem and environment unless everyone can adapt their lifestyles (Tuckett, 2019). This greenhouse effect became the main cause of the recent climate change on Earth (Weart, 2008). There is increase in temperature of Earth, melting of ice from the mountains, increase in sea levels, shifting of tree-lines towards the high altitudes, declining the water resources, loss of biodiversity etc. Twenty out of 864 species extinctions are considered extinct by the International Union for Conservation of Nature (IUCN) because of climate change (Cahill et al., 2013), increase in biological invasion, irregular rainfall etc. (Cavaliere, 2009). All regions, continents and

countries considered so far have experienced warming during the past century due to increasing anthropogenic radiative forcing (Estrada, 2021).

Scientists of different backgrounds have been studying the climate change, its causes, mitigation measures, impacts, resilience, adaptation and other concerned fields. Among them, the Botanists have contributed significantly. This paper unveils the concerned climate change studies made by the Botanists mainly from Nepal.

Materials and Methods

The studies made by the Botanists from Nepal in field of climate change studies were` downloaded with the help of the keywords such as Botanists, Climate change studies, Nepal in Google Scholar. Altogether 32 publications acquired are enlisted in the Annex. The number of papers/publications in a particular field authored by Nepalese Botanists were obtained.

Total number of papers were grouped according to the date of publication. Papers categorized according to the field of study. Citations were retrieved and compared to recognize top five papers (publications) with maximum citations.

Result and Discussions

Thirty two publications (annex) on the Climate Change studies by Nepalese Botanists were obtained. Altogether 31 publications, have the lead authors from Nepal. However, there were total of 113 authors/contributors including Nepalese Botanists. Among them there were total 84 Nepalese authors. Other 29 coauthors were foreigners. All of the studies were categorized in 12 subtitles based on their similarities (Table 1.).

Table1. Field within climate change and the number of publications

SN	Field of Study	No of publications
1	Impacts of Climate Change	5
2	Biological Invasion	4
3	Tree-line Shifts	3
4	Land use Change, Biodiversity	3
5	People's Perception	3
6	Medicinal and Aromatic Plants (MAPs)	
7	Ethnobotany	3
8	Resilience, Knowledge	3

9	High Altitude Plants	2
10	Agriculture Adaptation	1
11	Fruit Production	1
12	Dendrochronology	1

The five topmost publications which have most citations are as follows (Table. 2). Works concerned with local perceptions (Chaudhary & Bawa, 2011), adaptation to climate change (Manandhar et al., 2011), tree dynamics (Gaire et al., 2018), biological invasion under climate change (Thapa et al., 2018), and Climate change and biological invasion (Shrestha & Shrestha, 2019) are the five topmost publications out of total 32. The source of citations was google scholar from which the citations were retrieved and compared during June, 2024.

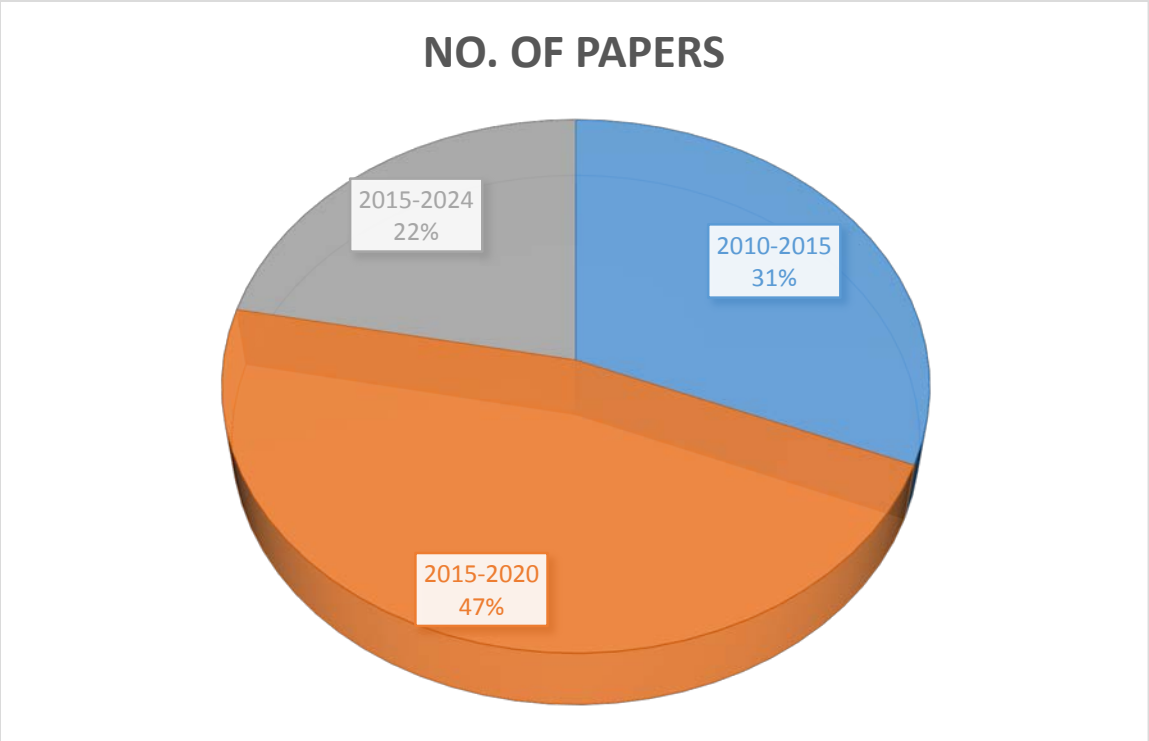
Table 2. The most cited works in climate change by the Botanists of Nepal

SN	Related field	Number of citations
1.	Local Perceptions on Climate Change-	373
2.	Adaptation on Crop Production Under Climate Change	351
3.	Tree Dynamics under Climate Change	201
4.	Predictions of Distribution of IAPS under Climate Change	172
5.	Climate change and biological invasion	116

Among others, climate change and distribution of MAPs (4 citations), High altitude plants (28 citations), Biodiversity and land use (21 citations), Horticulture (17 citations), Impacts on biodiversity (62 citations), Climatic upshot on growth of Pinus (30 citations), NTFPs (38 citation), Dendrochronological study (37 citations), Alpine vegetation and climate change (84 citations), , Treeline shift (41citations), MAPs distribution (24 citations), Ethnobotany of Yarsagumba (4 citations), Medicinal plants and ethnomedicines (24 citations), Invasive plant species in the Himalayas (55 citations), Vulnerability impacts on forest and wetlands (74 citations), IAPS in Nepal (83 citations), Land use, socio-economy and biodiversity (77 citations), Sustainability, habitat (25 citations), Perceptions, trends and impacts (32 citations), Perceptions of highlanders (64 citations), Impacts of climate change on distribution of Pterocarpus (23 citations), Impacts on distribution of MAPs (57 citations), Building knowledge on climate change resilience (No citations), Using local observations of climate change to identify opportunities for community conversations (4 citations), Proceedings on National Conference on Water, Food Security and Climate Change (No citations), Climate change effects of Nepalese fruit production (27 citations),Impacts of

Climate Change on medicinal plants of the Himalayas (79 citations) and habitat suitability for *Dactylorhiza hatagirea* in predicted future climate had 28 citations.

Figure 1. Publication percentage during different time intervals.



Climate Change studies have begun since 2010 by the Botanists in Nepal. In India the climate change study began after 2008 (dst.gov.in) and it began in 2009 (Dong et al., 2010) in China. Maximum works on climate change was carried out during 2015 to 2020 (47%,15 publications) than during 2010 to 2015 (31%, 10 publications) and minimum during 2020 to 2024 (22%, 7 publications) (Figure 1).

Conclusions

This paper has explored that climate change study has been studied by both social and natural scientists from all over the world. It should be made a multi-disciplinary aspect of the discourse to find the causes, impacts and the possible solutions of the anthropogenic climate change prevailed on the Earth. The climate change studies started in Nepal by plant scientists in 2010. Thirty-two publications were made so far in the field of climate change by plant scientists till 2024. Forty-seven percent of work was carried out between 2015-2020. Most cited papers belong to local perceptions, adaptations, tree-line dynamics,

predictions of further distributions of invasive plants, impacts on Himalayan medicinal plants, etc. However, maximum publications are related to impacts of climate change, and climate change on biological invasion.

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Annex

Table 3. Authors, Coauthors, Title, Date of Publications and Retrieved Dates of the Studies

SN	Authors/Coauthors	Title of work	Date of Publication	Retrieved Date
1	Aryal, S., Bhuju, D. R., Kharal, D. K., Gaire, N. P., & Dyola, N.	Climatic upshot using growth pattern of *Pinus roxburghii* from western Nepal	2018	6/3/2024
2	Bhattacharjee, A., Anadón, J. D., Lohman, D. J., Doleck, T., Lakhankar, T., Shrestha, B. B., ... & Krakauer, N. Y.	The impact of climate change on biodiversity in Nepal: Current knowledge, lacunae, and opportunities.	2017	6/3/2024
3	Bhuju, D. R., Shah, S. K., Gaire, N. P., Bhandari, S., Timilsina, R. R., Sharma, B., & Thapa, U.	Environmental reconstruction and impact of climate change on vegetation at tree-lines of Nepal Himalaya	2016	6/3/2024
4	Burke, B. J., Welch-Devine, M., Rzonca, S., & Steacy, C.	Using local observations of climate change to identify opportunities for community conversations in Southern Appalachia	2020	6/3/2024
5	Chaudhary, P., & Bawa, K. S.	Local perceptions of climate change validated by scientific evidence in the Himalayas.	2011	6/3/2024
6	Gaire, N. P., Bhuju, D. R., & Koirala, M.	Dendrochronological studies in Nepal: Current status and future prospects.	2013	6/3/2024
7	Gaire, N. P., Koirala, M., Bhuju, D. R., & Borgaonkar, H. P.	Tree-line dynamics with climate change at the central Nepal Himalaya.	2014	6/3/2024
8	Ghimire, S. K., Bista, G., Lama, N. S., Craig, S. R., Lama, W., Gurung, T. N., ... & Lama, T. C.	Without the plants, we have no medicine: Sowa Rigpa, ethnobotany, and conservation of threatened species in Nepal.	2021	6/3/2024
9	Gurung, L. J., Miller, K. K., Venn, S., & Bryan, B. A.	Contributions of non-timber forest products to people in mountain ecosystems and impacts of recent climate change	2021	6/3/2024
10	Hydro Nepal.	Special Issue on Proceedings on National Conference on Water, Food Security and Climate Change in Nepal	2012	6/3/2024
11	KC, A., & Ghimire, A.	High-altitude plants in era of climate change: a case of Nepal Himalayas.	2015	6/3/2024
12	Khanal, S., Timilsina, R., Behroozian, M., Peterson, A. T., Poudel, M., Alwar, M. S. S., ... & Osorio-Olvera, L.	Potential impact of climate change on the distribution and conservation status of Pterocarpus marsupium, a Near Threatened South Asian medicinal tree species	2022	6/3/2024
13	Kunwar, R. M., Baral, K., Paudel, P., Acharya, R. P., Thapa-Magar, K. B., Cameron, M., & Bussmann, R. W.	Land-use and socioeconomic change, medicinal plant selection and biodiversity resilience in far Western Nepal.	2016	6/3/2024

14	Kunwar, R. M., Lamichhane Pandey, M., Mahat Kunwar, L., & Bhandari, A.	Medicinal plants and ethnomedicine in peril: a case study from Nepal himalaya	2014	6/3/2024
15	Lamsal, P., Kumar, L., Aryal, A., & Atreya, K.	Invasive alien plant species dynamics in the Himalayan region under climate change	2018	6/3/2024
16	Lamsal, P., Kumar, L., Atreya, K., & Pant, K. P.	Vulnerability and impacts of climate change on forest and freshwater wetland ecosystems in Nepal: a review	2017	6/3/2024
17	Mainali, K., Shrestha, B. B., Sharma, R. K., Adhikari, A., Gurarie, E., Singer, M., & Parmesan, C.	Contrasting responses to climate change at Himalayan treelines revealed by population demographics of two dominant species	2020	6/3/2024
18	Manandhar, S., Vogt, D. S., Perret, S. R., & Kazama, F.	Adapting cropping systems to climate change in Nepal: a cross-regional study of farmers' perception and practices	2011	6/3/2024
19	NAST.	Building knowledge for climate resilience in Nepal, Research Briefs, Khumaltar, Lalitpur	2013	6/3/2024
20	Rana, S. K., Rana, H. K., Ranjitkar, S., Ghimire, S. K., Gurmachhan, C. M., O'Neill, A. R., & Sun, H.	Climate-change threats to distribution, habitats, sustainability and conservation of highly traded medicinal and aromatic plants in Nepal.	2020	6/3/2024
21	Rana, S. K., Rana, H. K., Ghimire, S. K., Shrestha, K. K., & Ranjitkar, S.	Predicting the impact of climate change on the distribution of two threatened Himalayan medicinal plants of Liliaceae in Nepal.	2017	6/3/2024
22	Salick, J., Ghimire, S. K., Fang, Z., Dema, S., Konchar, K. M., & Collaborating authors	Himalayan alpine vegetation, climate change and mitigation.	2014	6/3/2024
23	Scheidegger, C., Nobis, M. P., & Shrestha, K. K.	Biodiversity and livelihood in land-use gradients in an era of climate change-outline of a Nepal-Swiss research project.	2010	6/3/2024
24	Shrestha, B. B.	Invasive alien plant species in Nepal	2016	6/3/2024
25	Shrestha, B., Tsiftsis, S., Chapagain, D. J., Khadka, C., Bhattarai, P., Kayastha Shrestha, N., ... &Kindlmann, P.	Suitability of habitats in Nepal for *Dactylorhizahatagirea* now and under predicted future changes in climate.	2021	6/3/2024
26	Shrestha, U. B., & Shrestha, B. B	Climate change amplifies plant invasion hotspots in Nepal.	2019	6/3/2024
27	Shrestha, U. B., Lamsal, P., Ghimire, S. K., Shrestha, B. B., Dhakal, S., Shrestha, S., & Atreya, K.	Climate change-induced distributional change of medicinal and aromatic plants in the Nepal Himalaya	2022	6/3/2024
28	Subedi, S	Climate change effects of Nepalese fruit production.	2019	6/3/2024
29	Thapa, L. B., Thapa, H., & Magar, B. G.	Perception, trends and impacts of climate change in Kailali District, Far West Nepal.	2015	6/3/2024
30	Thapa, S., Chitale, V., Rijal, S. J., Bisht, N., & Shrestha, B. B.	Understanding the dynamics in distribution of invasive alien plant species under predicted climate change in Western Himalaya.	2018	6/3/2024
31	Uprety, Y., Shrestha, U. B., Rokaya, M. B., Shrestha, S., Chaudhary, R. P., Thakali, A., . .. & Asselin, H.	Perceptions of climate change by highland communities in the Nepal Himalaya.	2017	6/3/2024
32	van Beek, M., Bleie, T., Dollfus, P., Gaenszle, M., Gellner, D., Grandin, I., ... & WC1H0XG, L.	European Bulletin of Himalayan Research.	2012	6/3/2024