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# Climate change and production of secondary metabolites in medicinal plants: A review

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**Abstract**
Plant secondary metabolites are unique source for pharmaceuticals, food additives, flavours, and industrially important bio-chemicals. Environmental factors viz., temperature, humidity, light intensity, water, minerals and $CO_2$ influence the growth of a plant and secondary metabolite production. Climate change is causing noticeable effects on the life cycles and distribution of the world's vegetation, including wild medicinal plants. These metabolites have shown potential in treating various ailments as these plants based drugs would be cost effective due to its abundance and temperamentally quite suiting to millions of our masses, as these plants and their remedies are in use from ancient times. A need for research to improve our understanding of climatic effects on medicinal plants is stressed in the present article. An attempt is being made here to review the influence of abiotic factors and future strategies for research on secondary metabolite production. The research on medicinal plants with respect to climate change is very sporadic and insignificant in comparison with other commercial crops. These groups of plants should not be left as they are potential sources of bio-molecules and neutraceuticals.

**Keywords:** Secondary metabolites, Climate change, medicinal plants

## 1. Introduction
Climate change has become increasingly recognized as one of the greatest challenges to humankind and all other life on Earth. Medicinal plants are highly valuable to human livelihood. WHO estimated that 60% of the world population and 80% of the population of developing countries rely on traditional medicine, mostly plant drugs, for their primary health care needs. [1] Anthropogenic climate change has already marked effects on species ranges and ecological communities around the world including medicinal plants. Intergovernmental panel on climate change (IPCC), stated climate change is ''Unequivocal''. [2] It is projected that there will be further increase in temperatures from 1.4°c to 5.8° by the year 2100 and by 2033 there will be extreme and unpredictable weather event as (Fig1):

- More frequent and heavier monsoon rainfall
- More frequent and hotter summer days
- Less frequent and lower dry season rainfall
- Stronger and more frequent storms with high winds.

The augmented emissions of greenhouse gases into the atmosphere (mainly elevated CO2 followed by methane and ozone) are the major cause of climatic changes observed today.
These changes cause stress and can affect the secondary metabolites and other compounds that plants produce, which are usually the basis for their medicinal activity. It is already forcing bio diversity and ecosystem to adopt shifting habitat, changing life cycle and the development of new physical traits. Plant species which are endemic to geographic regions particularly vulnerable to climate change may face high risk in near future. [3] So, the studies on impact of climate change on medicinal plants are severely lacking.
The ingredients of plants all interact simultaneously, so their uses can complement or damage other or neutralize their possible negative effect. In the treatment of complex cases the component of the plants proved to be very effective. Phytochemicals have proven to cure many ailments and specially lifestyle diseases. This will help to reduce the side effect of synthetic treatment of the chemical remedies.
The impact of climate change on medicinal plants both cultivated and wild is very significant. The need of the hour is to have a focused research approach especially on the accumulation of secondary metabolites of health significance. The research on medicinal plants with respect to climate change is very sporadic and insignificant in comparison with other commercial crops. It is the high time that, these group of plants should not be left as they are potential sources of bio-molecules and neutraceuticles [4]

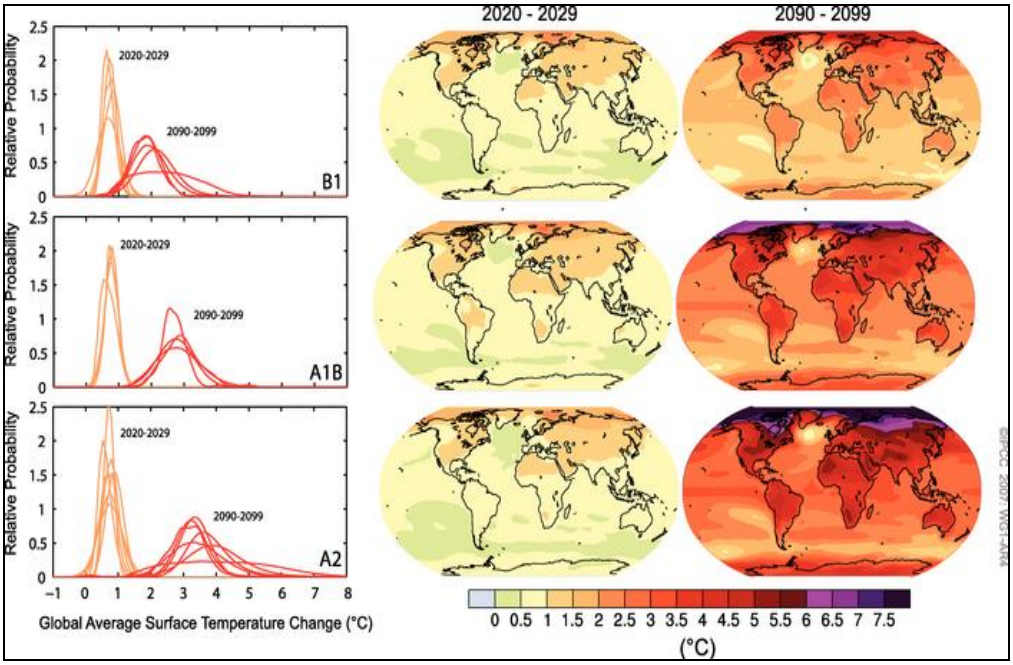


**Fig 1:** IPCC, 2007

## 2. Materials and methods

The method that has been used for impact of climate change on medicinal plants is assessed based on the recent literature, journal and some personal observation.

## 3. Results

The impact of climate change with respect to medicinal plants is discussed under the following heads.

- Phenological changes in selected species
- Shifting Ranges
- Effect of elevated $CO_2$ on productivity and quality
- Effect of elevated ozone levels
- Effect of Ultraviolet radiation
- Climate warming vs. secondary metabolite production
- Effect on threats to medicinal plants species
- Adaptation measures for climate change and global warming
- Mitigation measures to reduce emission of $CO_2$/GHGs

### 3.1 Phenological changes

The life cycles of plants correspond to seasonal cues; global climate change is affecting species and ecosystems. Rare medicinal plant species are under significant risk of threat from these phenological changes. Important phenological events for medicinal plants are adapted to climate change might be considered as (i) Bud burst and Leaf unfolding, (ii) Flowering and setting fruit, (iii) Autumn or dry season leaf drop, and (iv) The related processes of winter hardening and breaking As global warming progresses, it will affect the arrival of spring and the length of the growing season. [5]

### 3.2 Shifting Ranges

Changes in climate are also causing plants to migrate into new ranges. Their ranges have begun to shift towards the poles and/or to higher elevations in an effort to "reclaim" appropriate growing zones. Habitat loss and migratory challenges related to climate change could result in extinctions of many endemic species throughout the world. [6]

### 3.3 Effect of elevated $CO_2$ on productivity and quality of medicinal plants

In controlled environments, experiments have shown beneficial effects of elevated $CO_2$ on productivity and quality of various products and constituents of medicinal plants.

Elevated $CO_2$ levels (3,000 µl $CO_2$/litre of air) increased fresh weight and leaf and root numbers in cultures of lemon basil (*Ocimum basilicum* L.), oregano (*Origanum vulgare* L.), peppermint (*Mentha piperita),* spearmint (*Mentha spicata* L.) and thyme (*Thymus vulgaris* L.) shoots compared with cultures grown on the same media under ambient air. [7]

### 3.4 Effect of elevated ozone levels

Changes in $O_3$ concentrations can alter the production of secondary chemicals in plants. Plant physiological stress imposed by augmented $O_3$ levels may stimulate the induction of metabolic pathways (e.g., salicylic acid and jasmonic acid pathways) involved in the production of secondary compounds. [8]

### 3.5 Effect of Ultraviolet radiation

These radiations can cause molecular and cellular damage; for example, it can damage proteins, DNA and other biopolymers. [5] Furthermore, this type of radiation can affect plant growth and development and result in changes in vegetative or reproductive biomass, height, leaf characteristics, and flowering time. [9]

### 3.6 Climate warming vs. secondary metabolite production

The responses of secondary chemicals to increased temperature are less understood, although, an increase in volatile organic compounds has been generally detected. [10]

### 3.7 Effect on threats to medicinal plants species

Species that rely on each other (Co-existence) if no longer co-occur in the same time or space, in such cases, both may be driven to extinction. Pests, diseases and invasive species may spread into new ranges putting more pressure on fragile communities including medicinal plants. Conservative species with specific habitat requirements or long generation times are more prone to the threat of extinction. [11]

### 3.8 Adaptation measures for climate change and global warming

Future vulnerabilities of medicinal plants to climate change

can be reduced by conservation of endangered flora and fauna. These will include cultivation of medicinal plants. Maintaining genetic diversity in natural ecosystem is a key to adaptation of medicinal plants Traditional indigenous knowledge that can avert climate change impacts should be examined and documented, while promoting traditional art and craft based livelihood through involvement of local communities and income generation through eco-tourism. [12]

### 3.9 Mitigation measures to reduce emission of $CO_2$/GHGs

The medicinal plants of perennial nature like trees and shrubs may have valuable mitigation potential through carbon sequestration. Other mitigation measures include resource conservation, organic farming, mulching etc. [13]

### 3.10 Status of some medicinal plants in context of climate change

**Table 1**

| Name | Local name | Status | Uses |
|---|---|---|---|
| *Aconitum ferox* | Vatsanabha | Vulnerable | Extremely poisonous; used in leprosy, fever, cholera, nasal catarrah, tonsillitis, sore throat, gastric disorders and debility [14] |
| *Centella asiatica* | Brahmi, Gotu-kola | Endangered | Used in chronic dysentery, poultices are applied on carbuncle, cuts as antiseptic in wounds. [15] |
| *Dalbergia latifolia* | Satisal | Vulnerable | Used for fuel and timber. Bark is used for body ache, ulcers, wounds, eczema and pimples. [16] |
| *Drymaria cordata* | Laijabori | Vulnerable | Leaf paste is used in headache and in sinusitis. It is also used as vegetable and used for rejoining of broken bones. [17] |
| *Gloriosa superb* | Kalihari | Endangered | In ancient times used in arrow poison, causes powerful contraction of uterus, used in the treatment of gout, infertility, open wounds, snakebite, ulcers, arthritis, kidney problems and typhus. [18] |
| *Nelumbo nouchali* | Baga bhet | Endangered | Known as a neutraceutical. Fruits are eaten raw and the flowers are eaten fried. [19] |
| *Pterocarpus santilanus* | Chandan | Endangered | Tree is commercially valuable for its timber, medicine and cosmetic property [20] |
| *Rauwolfia serpentina* | Sarpgandha | Endangered | The drug is important therapeutic agent as anti-hypertensive. Root extract is used in relief of various central nervous system disorders like anxiety, schizophrenia and epilepsy.[ 21] |
| *Rhododendron leptocarpum* | Burans, Kavak | Critically Endangered | Flower is effective in diarrhoea and dysentery. The dried twigs and wood are used against phthisis and chronic fever. [22] |
| *Saussurea obvallata* | Brahma kamal | Endangered | It has bitter taste and used to treat fevers, liver ailments and urogenital disorders. [23] |
| *Swertia chirayita* | Chirayita | Vulnerable | Reduces fever, odema and very effective in malarial fever.[24] |
| *Withania somnifera* | Ashwagandha | Vulnerable | An adaptogen, used in debility, ulcers and Cardiovascular ailments. [25] |

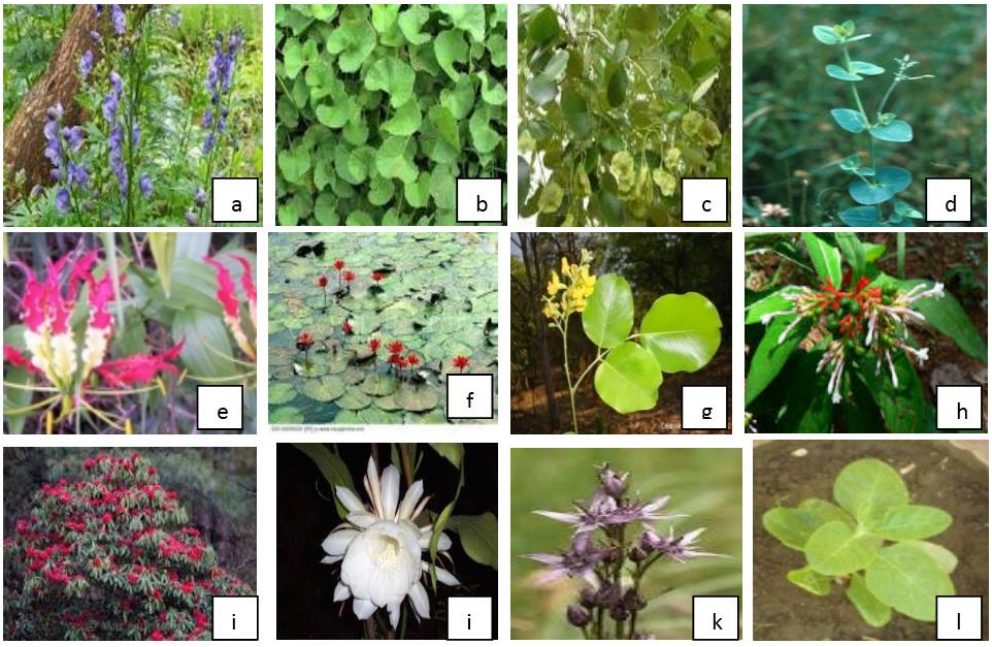


**Fig 2: a-** *Aconitum ferox,* b-*Centella asiatica,* c-*Dalbergia latifolia,* d-*Drymaria cordata,* e-*Gloriosa superba,* f-*Nelumbo nouchali,* g-*Pterocarpus santilanus,* h-*Rauwolfia serpentina,* i-*Rhododendron leptocarpum,* j-*Saussurea obvallata,* k-*Swertia chirayita*, l-*Withania somnifera*

## Conclusion

The endemic plant species are considered more vulnerable to climate change and may face high risk of extinction. Studies in other part of the world indicate that climate change is causing noticeable effect on life cycle of medicinal plant. Therefore, an improved knowledge of the factors responsible for such change requires intensive and continuous field survey. There is a need for establishing Long Term Ecological Research (LTER) station network in different eco-regions of India. Moreover further research on threatened medicinal plant under climate change scenario is essential for developing conservation strategies as well as practicing of cultivating medicinal plants through the involvement of local communities with the traditional indigenous knowledge can avert the impact of climate change.

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