ISSN 0376-5156
Geophytology 50(1&2): 147–152
May 2022

Predicted impacts of climate change on Upper Ganga Ramsar site in India

Arti Garg

Botanical Survey of India, Central Regional Centre, 10 Chatham Lines, Allahabad–211002, India. E-mail: kad_arti396@yahoo.com

Manuscript received: 17 January 2022
Accepted for publication: 22 February 2022

ABSTRACT

Garg A. 2022. Predicted impacts of climate change on Upper Ganga Ramsar site in India. Geophytology 50(1&2): 147–152.

The Upper Ganga Ramsar site in Uttar Pradesh harbours rich floral constituents of 419 angiospermous plant species comprising economical, medicinal, traditionally important and sacred plants while also sustaining the world's tenth largest Banyan tree, two sacred groves, one sacred site and a huge population of rose-ringed parakeets. The site is also a habitat for some rare and threatened faunal elements. Impacts of climate change resulting from elevated atmospheric temperature and carbon dioxide concentration followed by alterations in precipitation are predicted in terms of sustenance of botanical resources of this riverine Upper Ganga Ramsar Site of India.

Keywords: Climate change, Elevated temperature, Precipitation, Upper Ganga Ramsar site, Uttar Pradesh.

INTRODUCTION

The Ganga River arises from Gangotri (alt. 7010 m), Uttar Kashi District, Uttarakhand, on southern slopes of the Himalayan range, flows through Uttarakhand, Uttar Pradesh, Bihar and West Bengal covering 2525 km to join the Bay of Bengal. Ramsar precincts of the Ganga River expands over c. 11364 ha area, from Brijghat in Ghaziabad District to Narora in Badaun District, between 28°10'26" and 28°47'18" N and 78°07'04" and 78°25'57" E (Figure 1). Here, the river is shallow with intermittent deep-water pools endowed with many riverine islands and open-waters extending to almost 50% of the wetlands, with air and water temperature ranging from 11.5–35.5°C and 15.6–30.2°C respectively. Its direct catchments include 12 km buffer area sprawled over 254482 ha, with c. 130 wetlands endowed with countless ecological communities, many threatened species such as the endangered Gangetic Dolphins (*Platanista gangetica* subsp. *gangetica*) and more than 20000 water birds (Figure 2.G, I, K), thereby, fulfilling the ramsar criteria 2 and 5 of Ramsar sites (Murthy et al. 2013). The water depth varies from 300 cm to 362 cm in wet season and from 50 cm to 150 cm in dry season and transparency ranges between 3 and 5 cm during monsoon. Irregular water discharge from reservoirs of upper reaches and inconsistent rainfall in the area cause irregular flow of the Ganga River (NATCOM 2004) causing disturbance to the natural habitat of different aquatic animals. The entire region has a rich assemblage of phytoplanktons, zooplanktons, fishes, reptiles and birds including many red listed species of these and about 419 species of plants, both hydrophytic and terrestrial. The Gangetic wetlands are used for irrigation, fishing, pilgrimage, mass religious bathing and post-cremation activities while surrounding areas are used for agriculture, grazing, nesting and basking ground for turtles and crocodiles. Protected areas within this Ramsar site are wanting,

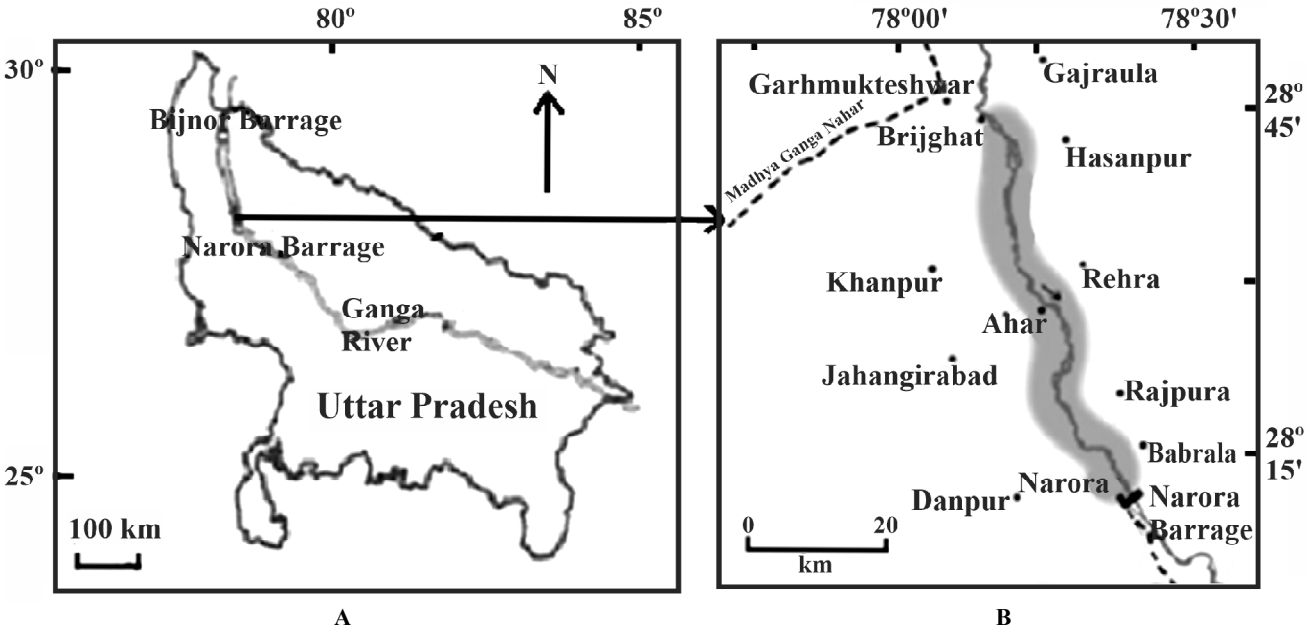

Figure 1. A. Map of Uttar Pradesh showing the course of Ganga River. **B.** Upper Ganga Riverine Ramsar Site (Brijghat to Narora Stretch). **Source:** https://sandrp.files.wordpress.com/2018/03/indias_wetlands_in_peril_feb_2011.pdf

for *in situ* conservation of the endangered species. Proclaimed as the only 'riverine ramsar site of India' in the year 2005, the site boasts a high biodiversity significance.

MATERIAL AND METHODS

Field surveys and plant specimen collection tours were conducted under the Ministry of Environment, Forest & Climatic Change (MoEFCc) – Botanical Survey of India (BSI) project on Floristic Diversity of Upper Ganga Ramsar Site during 2012–2017 to inventorize the plant resources of this ramsar site. All plants were identified using standard methods and deposited in the BSA (Herbarium, Botanical Survey of India, Central Regional Centre, Allahabad). Interactions and discussions were made with the World Wildlife Fund office staff located in Bulandshahr and correlated with visual observations on biodiversity conservation and river water status as well as interacting with the local people, pilgrims, saints, sagas and hermits. Information was also gathered on the religious importance and sacred attributes through these people as the Ganga River is a centre of religious offerings and most *ghats* are used for various religious rituals having tourist importance. People use the river water for holy bath, cremation and post-cremation ritual activities, domestic sewage disposal, industrial waste discharge, unspecified agricultural runoff, over-fishing, etc. Besides, population pressure, urban development, expansion of settlements, pesticide/ herbicide and fertilizer sprays in agricultural fields, river bank erosion and fluctuation in water-level expose the river ecosystem to various threats.

RESULTS AND DISCUSSION

Floristic survey of the Upper Ganga Ramsar Site: Floristic surveys revealed rich diversity of angiospermous plant species comprising economical, medicinal, traditionally important and sacred plants including significant species *viz. Alternanthera philoxeroides* (Mart.) Griseb. *Arundo donax* L., *Bacopa monnieri* (L.) Wettst., *Nymphaea rubra* Roxb. ex Andrews, *Enydra fluctuans* Lour. and *Salix tetrasperma* Roxb. Occurrence of *Amsinckia calycina* (Moris) Chater (Figure 2.A), within the ramsar precincts representing the only locality in India, and of *Carex fedia* Nees, *Elaeocarpus serratus* L., *Emilia javanica* (Burm.f.) C. B. Rob., *Inula falconeri* Hook.f. and *Schoenoplectus articulatus* (L.) Palla (*Cyperaceae*) conserved within its bounds,

corroborates the role of ramsar site in species conservation.

Macrophytes of Gangetic wetlands (Figures 2.A–F, H, J**):** The dominant wetlands macrophytes were *Azolla pinnata* R. Br., *Ceratophyllum demersum* L., *Eichhornia crassipes* (Mart.) Solms. (Figure 2.C), *Hydrilla verticillata* (L.f.) Royle, *Hygroryza aristata* (Retz.) Nees ex Wight & Arn., *Ipomoea aquatica* Forssk., *Lemna perpusilla* Torrey, *Ludwigia adscendens* (L.) Hara, *Najas minor* All., *Nelumbo nucifera* Gaertn. (Figure 2.D), *Nymphaea nouchali* Burm.f. (Figure 2.E), *Nymphoides hydrophylla* (Lour.) Kuntze*, Potamogeton crispus* L. (Figure 2.B)*, P. nodosus* Poir., *P. pectinatus* L., *Pseudoraphis spinescens* (R.Br.) Vickery, *Spirodela polyrhiza* (L.) Schl., *Trapa natans* var. *bispinosa* (Roxb.) Makino, *Utricularia aurea* Lour., *U. stellaris* L.f., etc. whereas the shoreline areas were infested with emergent macrophytes such as *Alternanthera sessilis* (L.) R. Br. ex DC., *Ammannia baccifera* L., *Eichhornia crassipes* (Mart.) Solms., *Hygrophila auriculata* (Schumach.) Heine, *Ludwigia adscendens* (L.) Hara, *Persicaria barbata* (L.) H. Hara, *Ranunculus sceleratus* L., *Phyla nodiflora* (L.) Greene, *Sacciolepis interrupta* (Willd.) Stapf, *Schoenoplectiella articulata* (L.) Lye*, Typha angustifolia* L. (Figure 2.H), etc. The site also owns reputation of housing the world's tenth largest Banyan tree (Figure 2.J) *Ficus benghalensis* L. (Garg & Singh 2016), two sacred grooves (Garg & Singh 2013a, b), one sacred site (Garg 2017), the only population of rose-ringed parakeets in Uttar Pradesh (Garg & Joshi 2016) and an extremely rich population of highly economical *Manilkara hexandra* (Roxb.) Dubard (Figure 2.F), besides providing suitable habitat for rare and threatened faunal elements (Figure 2.G, I, K–L), the common otters (*Lutra lutra*), endangered crocodiles, *Gavialis gangeticus* and *Crocodylus palustris*, turtles (*Aspideretes gangeticus*) and populations of significant birds like *Coracias benghalensis* (the Indian roller bird, Figure 2.G), *Anser indicus* (Bar-headed geese, Figure 2.I) and *Pseudibis papillosa* (the rare Indian Ibis, Figure 2.K). It also furnishes a protected habitat to the last remnant 'endangered' populations of the 'National aquatic animal', the Gangetic Dolphins (*Platinista gangetica* Roxb. subsp. *gangetica*) (Figure 2.L).

IMPACT OF GLOBAL WARMING ON WETLANDS

The River Ganga: The river Ganga, a major glacier-fed river of India, is an important water resource for shoreline settlements and constitutes a fragile ecosystem, cutting several wetlands along its perimeter and buffer area. The receding of Himalayan headwater glaciers currently at a rate of 16 m per year are precursor to such climatic perturbations which accelerates temperature rise, monsoon drift and recurrent floods and droughts (Singh & Kumar 1997) in this susceptible riverine ecosystem. Alterations in climate spur multifarious adversities in the ecosystem which triggers overall decrease in number of rainy days causing drought-like situations on one hand, and concurrent increase in rainy-day intensity, creating flood events on the other. The existing climatic aberrations which have already decreased per capita availability of water in India by 3523 m^3 in 56 years from 1951 to 2007 are feared to cause further decline from c. 1820 m^3/yr in 2001 to as low as about 1140 m^3/yr in 2050 (Gupta & Deshpande 2004, NATCOM 2004, Ravindranath et al. 2006). The sweeping climatic fluctuations event in severe pressure on the water table and associated components, both flora and fauna, and their biological cycle in wetland ecosystems. Since 'water table depletion and river basin shrinkage' due to elevated temperatures is more pronounced and rapid on wetland ecosystems the climb-down interferes with their most important function of 'mitigating global impact of climate change'. The detrimental impacts of such climatic aberrations on this Gangetic 'riverine' ramsar site ecosystem of India are anticipated on the basis of climatic predictions, so that effective counteractive strategies may be evolved well in advance for protection and conservation of its floral, faunal and cultural heritage.

Predicted Climate change by 2050 and its impacts on the Ramsar site: With such magnificent biodiversity, the Upper Ganga Ramsar Site is alarmingly exposed to unforeseen threats of global warming under

elevated CO_2 concentration, increased temperature and precipitation aberrations. The annual mean surface air temperature is predicted to rise from 0.9° ± 0.6°C to 2.6°±0.7°C by 2030s and 2–3°C by 2050 (Anonymous 2010, Chaturvedi et al. 2010) with simultaneous increase in minimum and maximum daily temperature by 1–4°C towards the 2030s, doubling of CO_2, methane and other greenhouse gases concentration by 2050, ringing alarm of c.740 ppm by 2085 (Ravindranath et al. 2006). Such drastic warming is most likely to produce a catastrophic impact on the water resources reservoirs of the ramsar site, leading to increased droughts and congruent irreversible depletion of wetlands, associated forest patches and their biological resources, both flora and fauna.

Since water reservoirs and wetlands play pivotal role in maintaining hydrological and ecological equilibrium in nature, the ongoing increase in CO_2 levels and temperature rise causing wetland shrinkage is ascertained to be detrimental for biodiversity of the ramsar site. Climatic change driven forest cover depletion and shoreline erosion exacerbate flood risks, and trigger mass migration of avian fauna due to their habitat loss from island submergence and loss of nesting and breeding grounds, evoking divergent migration traits in pursuit of nesting and egg laying habitats under the drasticity of rippled food web, resulting in disarray of biological timings of species and their food resources. Depletion in bird strength consequents in pollinator deficiency of dependent floral resources creating a floral demographic depletion and imbalance in floral diversity patterns. The overall disorientation of avian strength therefore, implicates discrepancy in community and ecosystem equilibrium, a grim situation, derogatory for the Gangetic riverine ramsar site of India, and detrimental for criteria fulfilment to uphold its current esteem.

CONCLUSION AND RECOMMENDATIONS

Significant seasonal variability in wetland vegetation occurs in terms of open-water spread, during post-monsoon and pre-monsoon, which can exacerbate with cumulative changes in hydrologic cycle due to warming and shrinkage of aquifers under climatic influences, causing massive plant phenological and distributional shifts and altered behaviour of wetland species, both floral and faunal, congruent with increase in water requirements for agricultural and human activities.

While wetlands biodiversity plays important role in mitigation of climate change, the drastic impacts of climate change in turn, is detrimental for the wetland biodiversity causing shrinkage and depletion resulting in eventual and proportionate hindrance in mitigation of the drastic impacts. Wise use and conservation of water and wetland resources is therefore necessary for sustenance and long term management of floristic riches for enhanced sustenance of grasslands for water retention, fringe vegetation for shoreline protection, dense tree canopy to safeguard the atmospheric CO_2 concentration and global warming for mitigating the adverse impacts of climate change on wetlands in a broad perspective and ramsar sites in a narrower sense, in the interest of continuous carbon sequestration, maintenance of healthy ecosystem and uninterrupted food web. It is therefore, need of the hour, to generate awareness and alertness for prioritizing locations of immediate concerns of conservation, the Upper Ganga Ramsar Site topping the list, to develop strategies which would reinforce wetland ecosystems resilience for mitigating climatic pressures, both natural and human-induced, and evolving strategies for reversal of wetland losses.

The climate change models lead to a reduced soil moisture causing shrinkage of teak forests and expansion of deciduous forests. The 'depleted water resource', 'reduced carbon sequestration' due to destruction of carbon sinks and 'habitat fragmentation' and migration of species result in biodiversity depletion and diminished ingression of avian fauna due to habitat

→

Figure 2. A. *Amsinckia calycina* (Moris) Chater. **B.** *Potamogeton crispus* L. **C.** *Eichhornia crassipes* (Mart.) Solms. **D.** *Nelumbo nucifera* Gaertn. **E.** *Nymphaea nouchali* Burm.f. **F.** *Manilkara hexandra* (Roxb.) Dubard. **G.** *Coracias benghalensis* (Indian roller bird). **H.** *Typha angustifolia* L. **I.** *Anser indicus* (Bar-headed goose) Flock of birds. **J.** *Ficus benghalensis* L. **K.** *Pseudibis papillosa* (Indian Ibis) Flock of birds. **L.** *Platinista gangetica* subsp. *gangetica* (The Gangetic dolphin, Source: https://www.worldwildlife.org/species/ganges-river-dolphin). Figures G, I and K: Courtesy Mr. Jitendra Pandey, *Narora* Atomic Power Station, Narora.

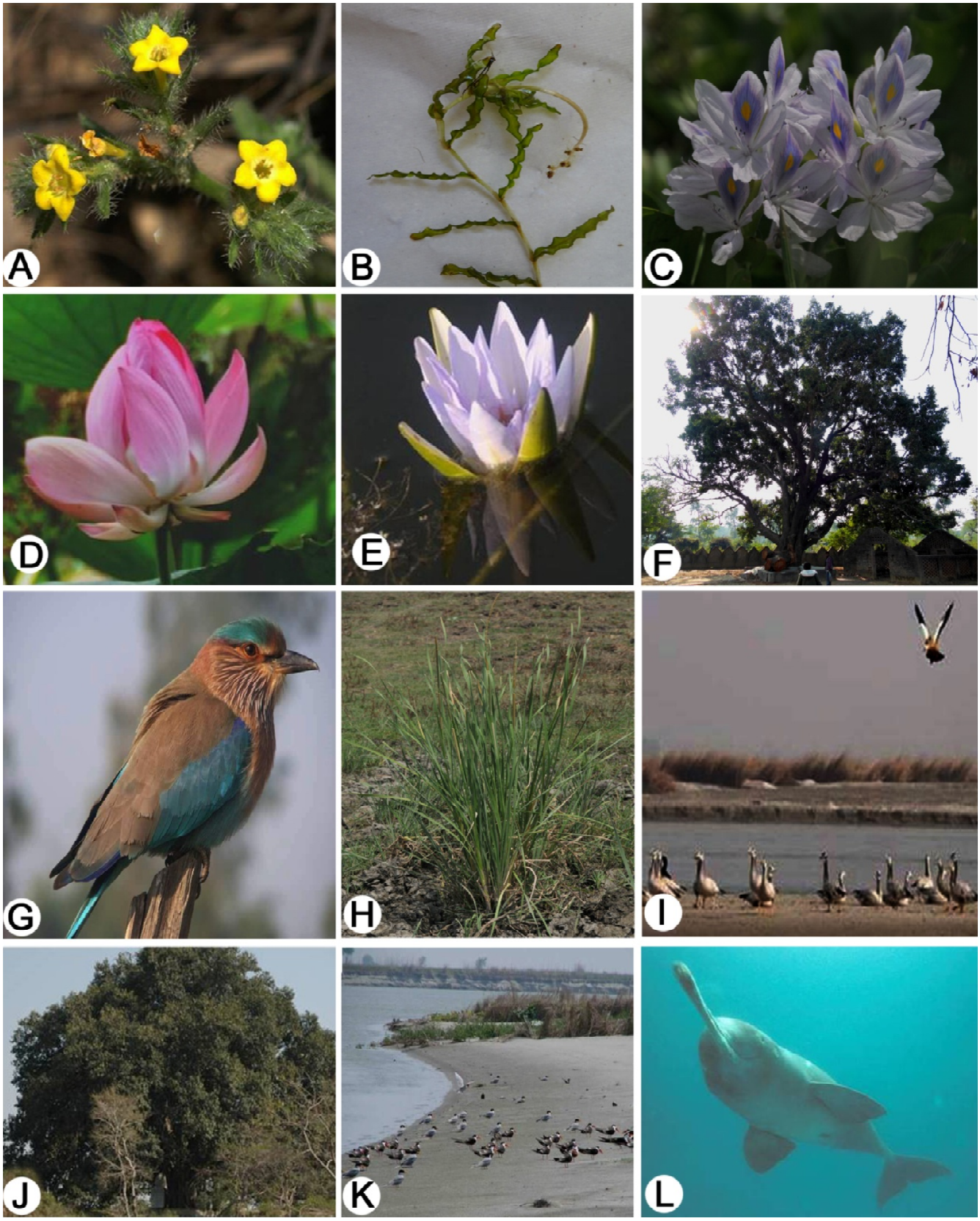

Figure 2

loss, generating 'divergent syndrome' among birds and capping ramsar site criteria on the whole. Consequent to pressures of climate change, the corresponding decline in avian species richness and their disoriented geographical distributions resulting from damaged breeding and over-wintering grounds, shrinkage in critical stopover sites resulting in potentially prolonged flight distances, are most hazardous, often detrimental for sustenance of the internationally important, but vulnerable ramsar site. Such drastic impacts of global warming calls for concerted and united approach to equip and formulate effective management measures to counteract unforeseen climatic adversities for upkeep and longevity of the pristine glory of this unparalleled riverine ramsar site of India.

ACKNOWLEDGEMENTS

The author is thankful to The Director, Botanical Survey of India (BSI), Kolkata for facilities and encouragement and to the World Wide Fund for Nature for field support.

REFERENCES

Anonymous 2010. Climate Change and India–A 4×4 assessment a sectoral and regional analysis for 2030. Report Ministry of Environment and Forests, Government of India.

Chaturvedi R.K., Gopalakrishnan R., Mathangi J., Govindasamy B., Joshi N.V., Raman S. & Ravindranath N.H. 2010. Impact of climate change on Indian forests: a dynamic vegetation modeling approach, Mitigation and Adaptation Strategies for Global Change, doi:10.1007/s11027-010-9257-7. Available at: http://www.springerlink.com/content/87g2376642867270/.

Garg A. 2017. Ambikeshwar sacred site in Upper Ganga–A repository of primeval flora and cultural wealth. Journal of Non-Timber Forest Products 24: 43–46.

Garg A. & Joshi B. 2016. Keystone trees in Upper Ganga Ramsar Site sustaining rose-ringed parakeets (*Psittacula krameri*). Indian Forester 143: 1039–1040.

Garg A. & Singh P. 2016. World's tenth largest Banyan tree at Narora in Upper Ganga Ramsar Site, Uttar Pradesh India. Current Science 111: 778–779.

Garg A. & Singh V. 2013a. Mandu sacred grove in Upper Ganga Ramsar site Uttar Pradesh. Current Science 104: 409–410.

Garg A. & Singh V. 2013b. Siddhwari sacred grove in Upper Ganga Ramsar site of Uttar Pradesh. Current Science 105: 1039–1040.

Gupta S.K. & Deshpande R.D. 2004. Water for India in 2050: First Order Assessment of Available Options. Current Science 86: 1216–1224.

Murthy T.V.R., Patel J.G., Panigrahy S. & Parihar J.S. 2013. National Wetland Atlas: Wetlands of International Importance under Ramsar Convention SAC/EPSA/ABHG/NWIA/ATLAS/38/2013,. Space Applications Centre (ISRO) Ahmedabad India.

NATCOM 2004. India's Initial National Communication to UNFCCC, Ministry of Environment & Forests Government of India.

Ravindranath N.H., Joshi N.V., Sukumar R. & Saxena A. 2006. Impact of climate change on forests in India. Current Science 90(3): 354–361.

Singh P. & Kumar N. 1997. Impact of climate change on the hydrological response of snow and glacier melt run off dominated Himalayan river. Journal of Hydrology 193: 316–350.