



**Figure 1.** *a*, A panoramic view of Sangetsar Lake; *b*, Nagula Lake situated at 4120 m amsl; *c*, Frozen Sela Lake during winter season at Tawang district, Arunachal Pradesh.

in the 2030s in IHR<sup>5</sup>. The Arunachal Pradesh State Action Plan on Climate Change has projected that maximum temperature will increase by 2.2°–2.8°C during 2030s compared to the baseline, i.e. 1961–1990 and towards 2080s the increase is projected to be 3.4°–5°C. Minimum temperature is projected to increase by 1°–2.6°C during 2030s and by 2.8°–5°C during 2080s. Water resource, forest and biodiversity are projected to be adversely impacted by climate change by the 2030s in Arunachal Pradesh<sup>6</sup>.

The fragile ecosystem and unique climatic conditions of HAWs are more vulnerable to the effects of climate change. They are characterized by extreme cold, dry and alpine climate conditions, particularly due to low air temperature and higher ultraviolet radiation. Researchers have also predicted hydrological and ecological response of HAWs to climate change in the Himalayan region<sup>1,7</sup>.

Climate change impact on HAWs can be visualized as the most significant because they provide numerous ecological services, support unique biodiversity, are

important for carbon sequestration, maintaining hydrological balance, livelihood benefits to dependent populace and have religious significance among indigenous communities. Therefore, there is an urgent need to undertake in-depth studies for sound database and formulate comprehensive climate change mitigation and adaptation strategies for conservation and management of pristine and vulnerable ecosystem of HAWs in Arunachal Pradesh. Education, awareness programmes, traditional ecological knowledge and community participation may also be encouraged to combat the climate change impact on HAWs of the state.

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K. S. KANWAL<sup>1,\*</sup>  
P. K. SAMAL<sup>1</sup>  
M. S. LODHI<sup>1</sup>  
J. C. KUNIYAL<sup>2</sup>

<sup>1</sup>*G.B. Pant Institute of Himalayan Environment and Development, North East Unit, Vivek Vihar, Itanagar 791 113, India*

<sup>2</sup>*G.B. Pant Institute of Himalayan Environment and Development, Himachal Unit, Kullu 175 126, India*

\**e-mail: kskanwal03@gmail.com*

## Conflicts, motivation and conservation

Traditional agro-pastoral activities in rural Uttarakhand (Western Himalaya), a hill state in India predominantly depend on the surrounding forests for fodder, fuel wood, dry leaves for animals bed. Approximately 64.80% geographical area of Uttarakhand is under forest cover, out of which 71.11% is reserve forest, 28.52% is protected forest and 0.35% is categorized as unclassified forest<sup>1</sup>. The unclassified forest also termed as civil forest area is open for biotic

activities like grazing, lopping of trees for fodder and collection of fuel. But these areas are subjected to overexploitation by the villagers and result in conflicts related to utilization of their resources. The Van Panchayats in Uttarakhand have actively involved the local people in conserving the unclassified forest areas and resolving conflicts for several years.

The first Van Panchayat was formed in 1921 in Kumaon division of Uttara-

khand<sup>2</sup>. Since then, over 12,000 Van Panchayats have been established in the state. These Van Panchayats were born out of rising conflicts around the forest areas. In 1980, one such conflict was reported between two villages of Bairagna Gram Panchayat (an administrative unit or council of few villages), namely Kunkuli and Siroli in Chamoli district, Uttarakhand over the lopping of *Quercus leucotrichophora* (Banj oak). At that juncture a few villagers from Kankhuli

approached Dasholi Gram Swaraj Mandal (DGSM), an NGO based in Gopeshwar which has been working on environmental conservation in mountain areas since 1964, under the guidance of environmentalist, Chandi Prasad Bhatt. DGSM and Bhatt suggested to the villagers to look into the revenue records, who found that the disputed unclassified forest land was the property of Kunkuli village. Thereafter, the villagers of Kunkuli were motivated by DGSM to protect the *Q. leucotrichophora* forest. Since then, approximately 6.0 ha area has been conserved and lopping or felling of green trees is prohibited. DGSM assisted the villagers to fence the area with a stone



**Figure 1.** Bird's eye view of protected and lush-green *Quercus leucotrichophora* (Banj oak) forest in Kunkuli village, Chamoli (Western Himalaya).

wall, which also helped in minimizing incidental grazing. The wall separating the village and the protected area has also helped the villagers overcome the damage caused by wild animals to their crops.

At present, around 20 households inhabit Kunkuli village and own nearly 60–70 livestock, including cows, buffaloes, sheep and goats. They continue to practice agro-pastoral activities. It is interesting to note that because of conservation practices, now trees such as *Myrica esculenta* (Kaphal), *Pyrush pashia* (Mehal) and *Rhododendron arboreum* (Burans) are also flourishing in this area. In order to protect this oak forest, the villagers prefer to walk 8–10 km in far forest for collecting fodder and fuel wood. The villagers used to collect dried leaves only for animals cushion and dried wood as fuel wood from this area, but now they collect wild edible fruits and flowers as well.

In 2010, the Forest Department started an experimental plantation of *Arundinaria falcata* (wild species of bamboo called as 'Ringal' used for rough weaving in hill areas) under oak trees. It has been observed that the plantation under the oak trees has also reduced the expansion of an invasive weed like *Eupatorium* sp. The villagers of Kunkuli feel that the area has developed and serves as

a habitat for wild animals like barking deer, Himalayan black bear, wild boar, wildfowl and porcupine.

The village has set a unique example of defensive and constructive participatory approach that has turned the village-level conflicts to embrace conservation (Figure 1). The village has therefore attracted several NGOs, and trainees of the Indian Administrative Service, and Indian Forest Service. Similar initiatives are required to restore the mountain ecosystem and conserve species that are vulnerable to climate change<sup>3,4</sup>.

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CHANDRA PRAKASH KUNIYAL

*Herbal Research and Development  
Institute,  
Mandal, Gopeshwar,  
Chamoli 246 401, India  
e-mail: cpkuniyal@rediffmail.com*

## Siddhwari sacred grove in Upper Ganga Ramsar site of Uttar Pradesh

According to the contemporary definition a sacred grove is 'a physically diverse patch of natural, primary forested enclosure of sacred trees and connected life-forms, revered by the endogamous clan for their supernatural association with religious or ominous attribute, or some alarming mythological anecdote, ascribed to a deity, devil or a demon, who is strongly bond with the woods conserved informally over generations to uphold these beliefs'<sup>1</sup>. Existence of sacred groves is of immense advantage in conservation of natural plant wealth through defence of the forest patch from anthropogenic pressures, with access restrictions based on traditional beliefs of the local clan that worships these plants/trees. Hence these segments of the forests become auto-conserved, virgin forests endowed with climax vegetation

and rich biodiversity, besides serving as a repository of many medicinal, palaeo-endemic and threatened taxa.

Known to exist since 1897 (ref. 2), the floristic and ethnobotanical studies of sacred groves were made from various regions in India mainly from Maharashtra<sup>3</sup>, Meghalaya<sup>4</sup>, Manipur<sup>5</sup> and several parts of the Himalaya<sup>6</sup>; however, their existence in any of the 25 Ramsar Sites of India was never revealed, although these internationally recognized wetlands hold highly rich mineral nutrients in their soil beds with availability of ample photosynthetic raw materials round the year. The favourable environmental conditions coupled with least anthropogenic intrusion makes them congenial for plant growth and sustenance of diverse vegetation. The Upper Ganga Ramsar Site is the only Ramsar Site of Uttar Pradesh cover-

ing a stretch of 85 km on the banks of the River Ganga from Brijghat (Ghaziabad district) to Narora (Bulandshahr district). Connected with various religious attributes, the inhabitants of this region uphold immense devotion and firm belief in ancestral deity worships. Therefore, the entire region is infiltrated with many ancient shrines and monuments of the Vedic era surrounded by diverse floristic components often of primary origin and sometimes venerated over generations on the belief of their connection to various sacred life-forms<sup>7</sup>.

During field survey and plant collection at the Upper Ganga Ramsar Site, we unearthed a small, unique and entirely secluded forest patch embedded within dense forest which was considered sacred by the local clan of 'Jatas'. This is the Siddhwari sacred grove. Situated on