COMMENTARY

Status of Himalayan yews in West Kameng district of Arunachal Pradesh

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Taxus, commonly known as yews, is a primary source of taxol used in the treatment of ovarian and breast cancers. It is found in the world's temperate forests and in Asia it occurs from Afghanistan through Himalayas to the Philippines. Owing to over exploitation, this species is disappearing rapidly. The present study in West Kameng district of Arunachal Pradesh, where maximum occurrences were reported, reveals that merciless and mass exploitation has converted the area into a 'death valley' of Taxus trees. Out of the 145 total plants located, 105 were dead trees. Efforts from stakeholders are essential for conservation and regeneration.

Taxus is a small to medium sized tree, with red 'berries' (seed covered by arils), valuable for taxol or paclitaxel extraction[1] used in the preparation of anti-cancer drugs, in addition to other medical uses in Ayurveda and Tibetian medicine[2]. It is a slow-growing evergreen tree found in the temperate forests at an altitude ranging between 1500 and 3000 m and in a least disturbed forest[3]. Natural regeneration is more pronounced under broken canopy[4]. Once the pacific yew had been the only source of taxol, but in 1995 Asian yew (*Taxus wallichiana* Zucc.), a closely related plant that grows in Himalayas, is listed in Appendix II of CITES[5]. It is found in temperate forest of Asia from Afghanistan through the Himalayas to the Philippines[2]. Taxol, a highly derivatized diterpenoid, has shown promises as an anti-tumour agent in breast and ovarian cancers. Although all 11 species of *Taxus* make taxol, the natural stands of these trees are often small and remote[6]. Moreover, only 0.01–0.03% of the dry phloem weight is taxol, yet as much as 2 g of purified taxol is required for a full regimen of anti-tumour treatment[7]. It is reported that a 20-year-old tree can yield up to 30 kg of leaves and 5 kg of barks which in turn produce 4 g of taxol priced at Rs 3 lakh at a very conservative estimate[3].

Taxol is being used in the treatment of the cancers like breast cancer, ovarian cancer, kaposi's sarcoma (an AIDS-related cancer) and over 20 such other indications. It is also used for coating of stents (anti-angiogenesis), alzheimer, multiple-sclerosis and polycystic kidney disease[8]. According to Cameron and Smith[8], the worldwide demand of taxol is 800–1000 kg annually; in North America and Europe alone the demand is 400 kg per year; the demand is growing at an annual rate of 20%; about 30,000 kg of the biomass of *Taxus baccatta* is needed to produce 1 kg of the paclitaxel and around 2–3 million kg of biomass is harvested annually whereas the sustainable rate of harvesting is estimated to be 0.6 million kg per year.

Since the first taxol-producing fungus *Taxomyces andreanae* isolated in 1993 (ref. 6), there have been few reports on isolation of taxol-producing endophytic fungi demonstrating that organism other than *Taxus* spp. could produce taxol[9,10]. Over the last decade there has been a great deal of interest in finding other fungi that produce taxol[11]. Several taxol-producing fungi have been identified, such as *Taxomyces andrenae*, *Pestalotiopsis microspora*, *Alternaria* sp., *Fusarium latritium* and *Periconia* sp.[12–16]. Although the endophytes isolated from the *Taxus* when cultured in the medium are found to grow taxol, the yield is very low. *P. microspora* isolated from *Taxus wallichiana* produces 60–70 μg/l culture whereas the yield from other species is less than 2 μg/l of paclitaxel[17]. All other alternatives for paclitaxel production, such as chemical synthesis, genetic engineering and tissue and cell cultures of *Taxus* species are expensive and give low yields[18,19]. Presently, taxol in the world's market has its origin only from the *Taxus* spp.[9].

In Arunachal Pradesh, the reconnaissance survey to assess the natural occurrence and distribution of *Taxus* indicates a wide distribution[3]. The ideal altitudinal zone where the tree occurs is between 2000 and 2500 m throughout the state in the temperate forest of Bomdila, Shergaon, Eagle Nest, Dirang, Thungri, Tawang, Mago and Zimithang in West Kameng and Tawang districts; Tale Valley (a few trees only) of Lower Subansiri, Anini, Mayodiya in Dibang Valley district; Mechuka in Siang and Melinja, and Hotspring areas of Lohit district[17]. In Arunachal Himalayas, it is associated with broad-leaved tree species like *Quercus lamellose*, *Quercus elegens*, *Rhododendron arboretum*, *Rhododendron grande*, *Ilexdiprina*, *Acer* spp., *Schefflera* spp., *Illicium griffitti*, *Salix* spp., *Tertracentron sinesis*, *Betula*, etc. and conifers like *Abies*, *Larix*, *Tsuga*, *Cupressus*, etc. and the associations vary from place to place depending upon the local conditions[3].

This work is an attempt to explore current status of *Taxus* species in Arunachal Himalayas, especially in those areas where its occurrences have been reported. The survey primarily focused on the status in the aftermath of large scale trade that occurred during 1990s. The *Taxus* leaves were mainly supplied from West Kameng district until the prohibition on the export of the species through its listing under *Negative Lists of Exports* by the Government of India in 1996. Further, the maximum occurrences are also reported from West Kameng. Therefore, a field survey was carried out in West Kameng district to assess the present status. The areas visited are Domkho, Morshing, Sanglem, Khelang, Phudung, Mandala, Dirang, Bomdila, New Bomdila and Palizi-Ramda, as shown in Figure 1. The latitudes, longitudes and altitude along the transact routes and points of the *Taxus* plants in field were recorded through Global Positioning System (GPS).

In Domkho, Morshing, Sanglem, Khelang, Phudung, Mandala and Dirang areas large-scale exploitation of *Taxus* plants has taken place during 1990s. Linear transects in the deep forests around the villages reveal many dead *Taxus* trees (Figure 2). Although few saplings

and seedlings were also found in these areas, their numbers are very less and found sparsely scattered and isolated. Some of the villagers in Domkho and Morshing have also ventured to cultivate *Taxus* plants in the farmyards (Figure 3). However, the rate and scale is insignificant to compensate the irreparable loss met to this resource. These planted *Taxus* are seen bearing cones during the field survey. Similar status of *Taxus* trees was observed in areas near New Bomdila and Palizi-Ramda. Near New Bomdila, the remnants of many dried up *Taxus* trees and few live *Taxus* trees are found along the steep slope. In Palizi-Ramda the villagers who were involved in *Taxus* trade earlier were employed to accompany the search operation. Only two big trees, one at the top of a hill and another along the steep hillslope, are located. Here too, we found many dry *Taxus* trees because of the complete extraction of leaves. The *Cephelotaxus* is abundantly available in these areas between Ramda and Palizi. In the absence of standard lopping method, the leaves were pruned mercilessly to the extent that the plant could not withstand to survive. Moreover, the pressing demands and associated lucrative price lured middlemen and villagers to plunder this scarce resource pushing it to the extreme limits of disappearance. The complete dryness of all harvested plants in the area reveals an unscrupulous way of exploitation for commercial purpose, turning these area into a 'grave yard' of this valuable species. Apart from the absence of standard lopping techniques, it also reveals non-existence of any regulatory mechanisms for sustainable harvest.

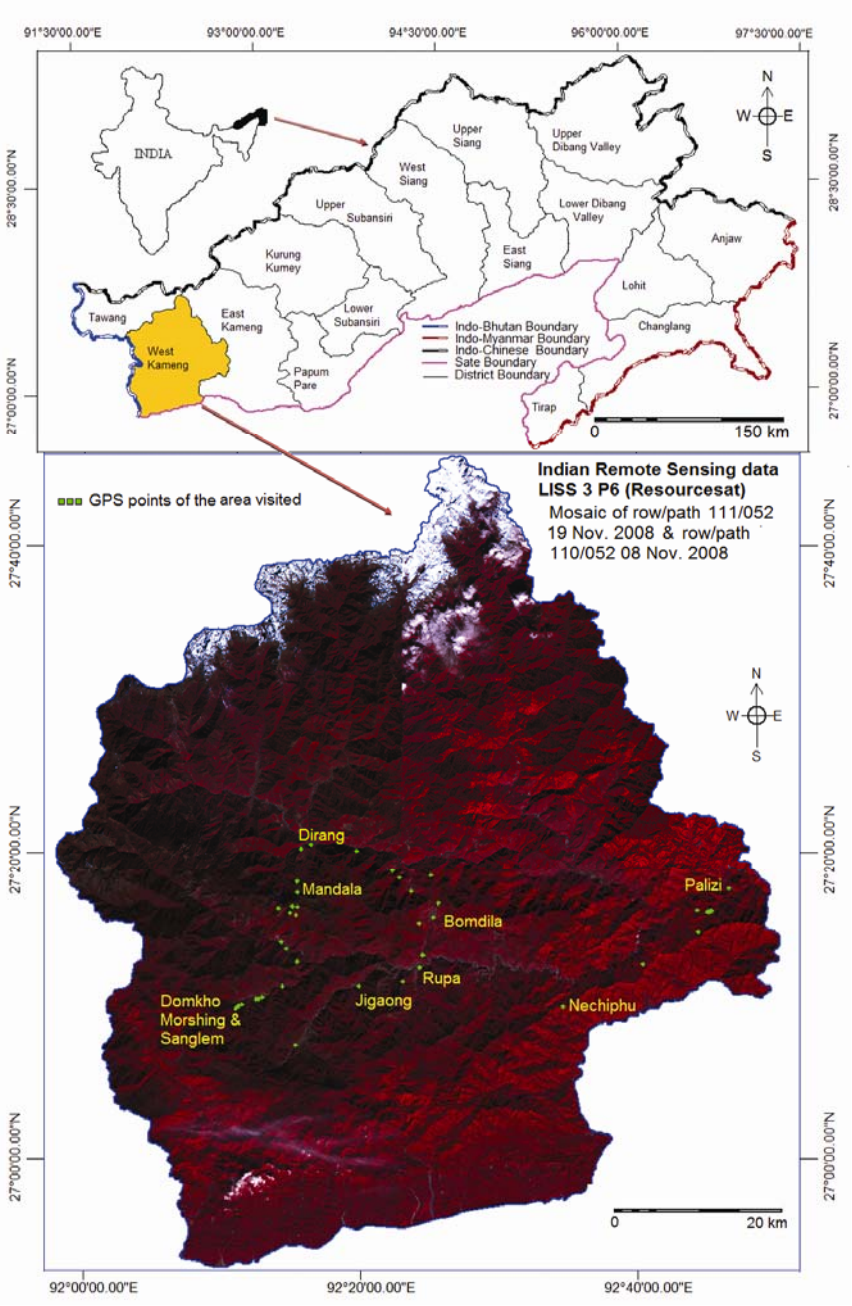

Figure 1. Study area with GPS points on top of IRS LISS 3.

Interaction with village elders, herdsmen, hunters, local body members, etc. revealed that *Taxus* (locally known as *Tesiang* or *Tesing*) was abundantly available in nearby forest. But, after the large scale supply of leaves, it is now not found within 8–10 km radius from these villages. They report that the stem of a well-grown *Taxus* tree was used for house construction. The hard and durable woods of the species were used for the main post or pillar of the houses. They also reported that *Tesing* (*Taxus*) leaves were fed to the cattle, especially to the Yak. It is still believed that the leaves of *Taxus* keep their cattle healthy and fetch them good quality milk and thereby the milk products (butter, cheese locally called *churpi*). Yak milk and milk product forms an essential part of Monpa food. There are some semi-nomadic people in the area known as *Brokpas* who live on transhumance herding. They migrate seasonally between the alpine grasslands to pastures of low lying areas along with their herds. During winter they descend down to low lying areas and in summer they climb towards alpine grasslands.

Linear transects in the vicinity revealed 145 *Taxus* plants. Out of which, 105 are dead trees. Among the live plants 20 are seedlings, 14 are saplings and 4 are full grown trees – one each near Sanglem and New Bomdila and another two between Ramda and Palizi. This provides a dismal picture and alarming situation in the area. Villagers also reported that about 70–80 trucks of the *Taxus* leaves were supplied each from Domkho, Morshing, Sanglem and Khelang villages. One truck load of *Taxus* leaves would need at least 30 full grown trees to be completely pruned. Thus, approximately 9600 full grown

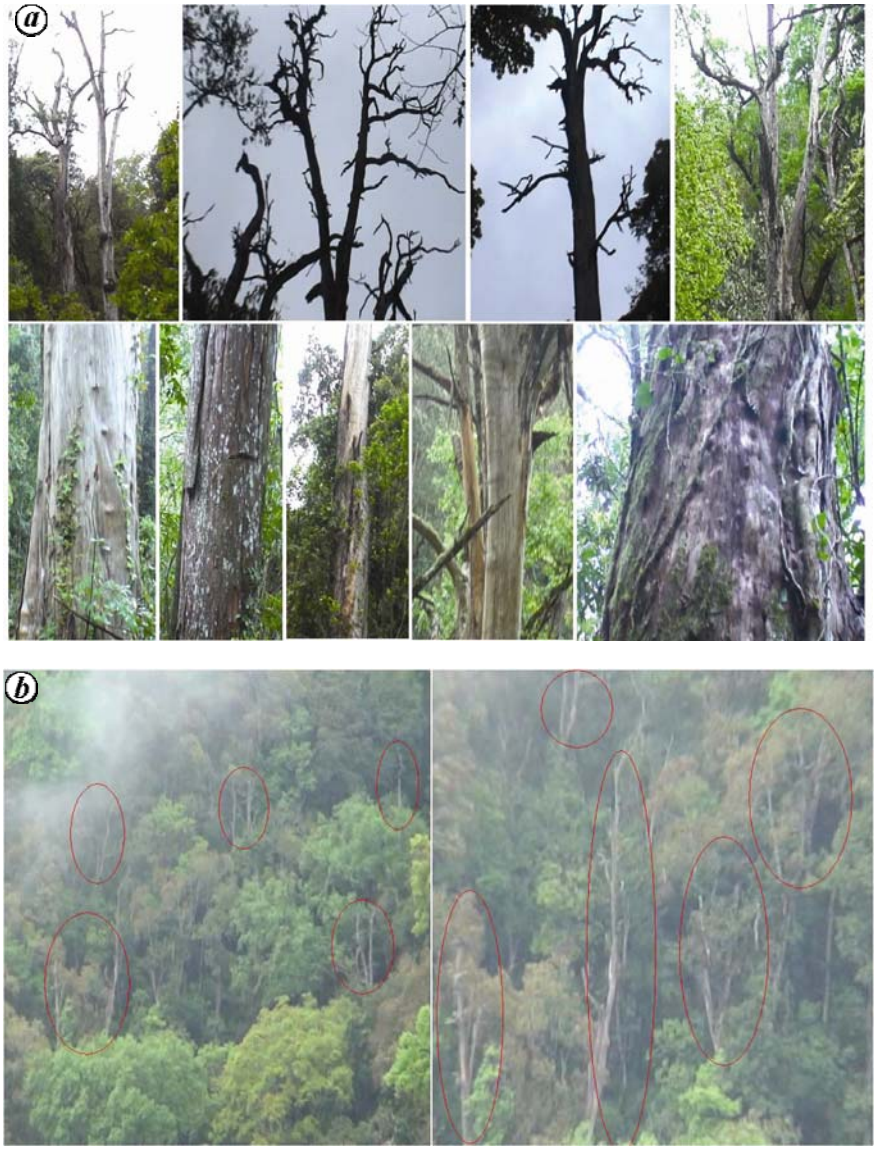

Figure 2. ***a***, Dead *Taxus* trees due to exploitation. ***b***, Dead stumps of *Taxus* trees in the dense forest.

Figure 3. *Taxus* plants in the farmyards.

trees have been completely destroyed from the surrounding areas. Surprisingly, even the seedlings or the young plants are conspicuous by their absence in the vicinity of dried up trees. This confirms the poor regeneration, germination and survival rates of the plant[17]. However, other factors which are playing inclusive roles may be feeding habits of browsing by wild animals, cattle and fowls which reportedly feed on young shoots, leaves and seeds of *Taxus*. The dense nature of forest with thick undergrowth may also have prevented the success rates of the seedlings as natural regeneration is reported more under broken canopy[4]. The clandestine trades on plant have also been reported by different government agencies and non-governmental organizations. The practice of transhumance pastoralism also demands pasture lands for the Yak and other cattle in different altitudes which is the major cause of forest degradation in general and loss of valuable temperate species in particular. The increasing demand of pasture land is met by clearing forest and setting fire, which sometimes also causes uncontrollable forest fire.

The *Taxus* in a natural stand is not available in the vicinity of Domkho, Morshing, Sanglem, Khelang, Phudung, Mandala, Dirang, Bomdila and Palizi-Ramda. Forest of these areas which were once rich in this species has now been turned into 'death valley'. Therefore, there is an urgent need for conservation and regeneration of this vanishing valuable resource. This can be achieved by systematic strategies through larger community awareness, community participation, suitable propagation techniques, *in situ* and *ex situ* trials, demonstration, financial and infrastructural assistance, adequate remuneration, etc. As the growth of plant and its survival rate are low, the regeneration of the plant involves risk and uncertainty to the villagers. Moreover, the regeneration also needs proper protection (fencing) against browsing animals feeding on the plants. Because of all these practicalities the farmers are reluctant to grow *Taxus* plants at their own even if it has great demand in the pharmaceutical industries. Therefore, more focus is needed on the financial assistance and remuneration to the growers to ensure large scale participation. More importantly, there is also a need of regulatory mechanism and standardized

harvesting techniques for the sustainable use of this resource.

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ACKNOWLEDGEMENTS. This communication is a result of the piecemeal efforts in accomplishing the objectives of Research Project funded by the Ashoka Trust for Research in Ecology and the Environment (ATREE) and Critical Ecosystem Partnership Fund (CEPF). We gratefully acknowledge the generous sponsorship of the funding Agencies.

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