

# Tea cultivation by the smallholders in hilly parts of Uttarakhand in north India: Ecological and socio-economic considerations

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**ABSTRACT:** Tea cultivation and processing was a well-established industry during the British period in the mountains of Uttarakhand State in northern India. Tea gardens, however, gradually got abandoned and even vanished for various reasons, with the departure of British. The Government of Uttarakhand initiated concerted efforts in 1995 to revive the tea industry with a view to generate employment and income for the locals. Many of the abandoned tea gardens were revived, as well as uncultivated community and private lands were brought under new tea plantations. This has generated enthusiasm among the locals, and the primary survey carried out with 168 small tea growers (STGs) of the region has revealed that this shift from small scale agriculture and animal husbandry to cash crop (tea) based livelihood has helped the marginal farmers, including women to improve their social status. Otherwise non-cultivable wastelands and abandoned croplands, now under tea plantations, are providing employment opportunities as well as additional income. Ecological considerations of tea cultivation are suggestive of following a cautious approach, since this involves the practice of monoculture on relatively large parcels of land. Further, it needs to be emphasized that the lessons learnt in the past (problems associated with the British tea industry in the region), as well as making the cultivation of tea more cost effective, should be adequately addressed to make this expanding activity sustainable, environment-friendly and socio-economically sound. Efforts are also needed to encourage organic farming of tea, improving quality and yield of tea using clones suitable for the agro-climatic zones, keeping in mind that the region experiences seasonally dry climate. It is felt that tea plantations should be encouraged keeping the above considerations in view and with a focus on STGs.

**Keywords:** Himalayan mountains; Small tea growers; Tea cultivation; Ecological and socio-economic considerations; Employment and income generation; Uttarakhand

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## Introduction

Tea is a popular beverage globally and its consumption is on the rise due to its positive effects on human health.<sup>1</sup> In India, tea accounts for 90.6% in terms of consumption of stimulants (tea, coffee, and cocoa beans). Average annual consumption of tea in India (0.72 kg per person; world average: 0.75 kg) is lower than countries such as Pakistan, Sri Lanka, Ireland, Turkey and UK (range = 1.0–2.96 kg per capita). In India, 159,190 tea gardens spread over 579,353 ha land were under operation until 2008. Among the four major producers of tea (China, India, Kenya and Sri Lanka) that collectively account for 71.2% of the total world production, India with an estimated production of 980 million kg (accounting for 27% of the total tea production) is the second largest producer in the world. In 2007 as per Tea Board of India, the Indian tea industry directly employs more than a million people, mostly backward and tribal (of which 70% are women), and directly or indirectly generates income and livelihood for more than 2 million people.

Small tea growers (STGs) have become a part of the Indian tea industry during the past few decades. The STG is a farmer who operates a micro-sized tea plantation, measuring <10 ha.<sup>2</sup> In India more than 4.15 lakh families are directly engaged with STGs gardens (Abdul Hanan; <http://www.sikkimuniversity.in>).<sup>1</sup> They were initially confined to Nilgiri district in Tamilnadu, and to a small extent in Kerala and Himachal Pradesh. The trend of growing tea over small areas has also spread to Assam, West Bengal and Bihar during the 1990s. In the recent past, in north India, Terai farmers in West Bengal resorted to tea cultivation as small growers due to non-remunerative price of pineapple.<sup>3</sup> Today, while 39% of the STGs are in Assam, Tamilnadu has 34%, North Bengal has 24% and Kerala has 10% STGs. Uttarakhand hardly figures in the tea-growing states. The tea gardens situated in the rural areas contribute significantly to the socio-economic development of the people in these regions.<sup>4</sup> Tea Board of India has proposed an outlay of Rs. 300 crore in 12th Plan to help STGs to become more organized so that they are able to avoid becoming vulnerable to intermediaries and factories ([www.teaboard.gov.in](http://www.teaboard.gov.in)).

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## History of Tea Cultivation in Uttarakhand

Tea cultivation in Uttarakhand (a mountainous state in north India) dates back to about 150 years when the first consignment of 20,000 tea seedlings from Kolkata reached this region in 1835, at the same time when plants were also sent to the hills of H.P., Darjeeling, Assam and South India.<sup>5</sup> A total of 63 tea gardens existed in Uttarakhand up to 1880, spread over an area of 4428 ha, and registering a production of 770,270 kg by 1897.<sup>6</sup> Some of the largest tea gardens in Uttarakhand measured up to 486 ha (the biggest among these was Arcadia Tea Estate, Dehradun), 205 ha (Malla Katyur) and 158 ha (Kausani). The Chaukouri and Berinag tea gardens (122 ha) were in peak production during 1940–1965, and alone employed 500 persons.<sup>6</sup> The production from tea gardens of Kumaun (Almora and Nainital districts of Uttarakhand; 1353 ha) amounted to 208,000 kg of made tea in 1900.<sup>7</sup> Few surviving estates around Dehradun manufacture green tea, which is supplied to Amritsar for export to Pakistan and Afghanistan; apart from being original Chinery type, it is purely organic. Dehradun Tea Company Ltd. Arcadia, today manufactures 70,000 kg of green tea every season, which is much less as compared to 35,00,000 kg manufactured two decades ago.

In spite of the glorious past, tea industry in this region faced steady decline due to several socio-economic and political reasons. Apparent labour problem, lack of adequate fuel, and cost of packaging and transportation to Calcutta (now Kolkata) during 1880–1924 were some of the problems faced by the tea industry of Bhimtal–Sattal area (Kumaun hills), where tea was introduced in 1842. Many of the tea gardens in the area slowly got converted to growing temperate fruits (peaches, plums, pears, apricots, citrus, *etc.*), and subsequently apple and potato were introduced to Kumaun during 1925–1950. As a result, the number of tea gardens reduced from 63 to 20 in 1911 (858 ha), and the production declined to 47,250 kg in 1908.<sup>6,8</sup> Falling production levels, lack of expert labour and increased operational costs collectively forced owners to sell their tea estates.<sup>9</sup> After independence, rampant encroachments, ever dwindling skilled labour, cattle grazing and fast spread of invasive weeds like Lantana added further problems to these estates. Rising land prices after Dehradun was made the capital of Uttarakhand also resulted in many of these estates getting converted into residential colonies.<sup>9</sup> A survey with 50 people associated with 15 tea gardens of the British period in Uttarakhand revealed (in order of importance) that: (i) Hike in labour wages and shortage of skilled

labour due to other opportunities/alternatives for livelihood and out migration following independence; (ii) Market competition due to availability of tea from outside at competitive rates; (iii) Emphasis on agriculture; (iv) Lack of local tea factories, poor technical knowledge amongst the locals about tea cultivation and processing; (v) Absence of good transport facilities and local markets; (v) Careless attitude of the garden owners and lack of silvicultural management; and (vi) Mismanagement of tea gardens and factories were the major reasons of failure of tea industry in this region.<sup>10</sup>

## Revival of Tea Cultivation in Uttarakhand

Keeping in view the scope and importance of tea in strengthening the socio-economic conditions of small and marginal farmers, potential of employment generation for unemployed youth through tea cultivation, the State Government (the then Uttar Pradesh) decided to reintroduce tea in Uttarakhand hills in 1987, by taking uncultivable farmlands and community wastelands on lease and reviving abandoned tea gardens of the British period. After the initial introduction of Kangra Jat (brought from Kangra, H.P.), its further expansion was stopped due to low yield in spite of assured good quality of made tea. During 1993–1994, Government sanctioned “Uttarakhand Tea Development Project”, which was implemented by Kumaun Mandal Vikas Nigam, Nainital. After the creation of Uttarakhand (UK) state in November 2000, “Uttarakhand Tea Development Board (UTDB)” was formally set up by the Government on February 12, 2004, with the specific mandate of overall development of the tea sector in the state ([www.utdb.gov.in](http://www.utdb.gov.in)). In 1994, Dr. M.B. Tamang, a tea specialist from the Institute of Himalayan Bioresource Technology, Palampur (H.P.) was invited to visit this region; he advised that high tea yields like Assam, West Bengal or South India are unlikely to be achieved in the hills of UK; this loss in yield should be compensated for by growing high quality of tea with Darjeeling type flavour. He recommended various tea varieties with different spacing and number of tea bushes per/ha for four altitudinal zones in Uttarakhand. Thus, highly flavoured standard Darjeeling tea clones along with some high-yielding clones with average flavour such as Takdah-78, Ambari AV2, Upasi-9, TS-378, TS-520, Assam BSS, *etc.*, were used in upcoming tea plantations in Uttarakhand.<sup>11</sup> In 1997, yield of made tea in plantations of various ages and prune/skiff regimes was recorded to range from 41 kg ha<sup>-1</sup> (2-year-old plantation) to 646 kg ha<sup>-1</sup> (2810 kg ha<sup>-1</sup> green leaf) for 11-year-old plantation.<sup>11</sup> In 2002, based on the fine-

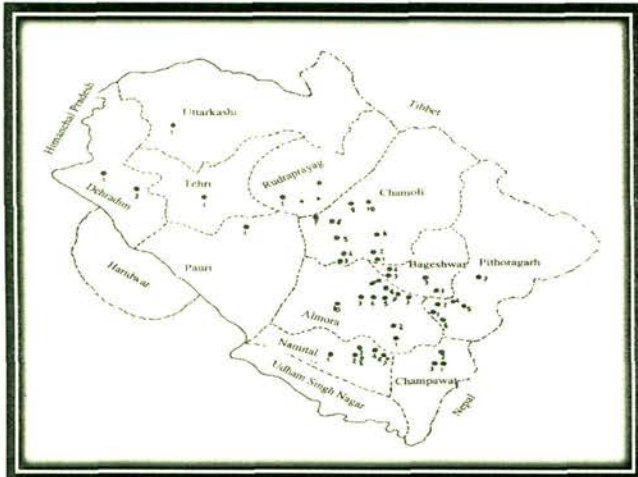


Figure 1. Location of tea gardens in Uttarakhand.

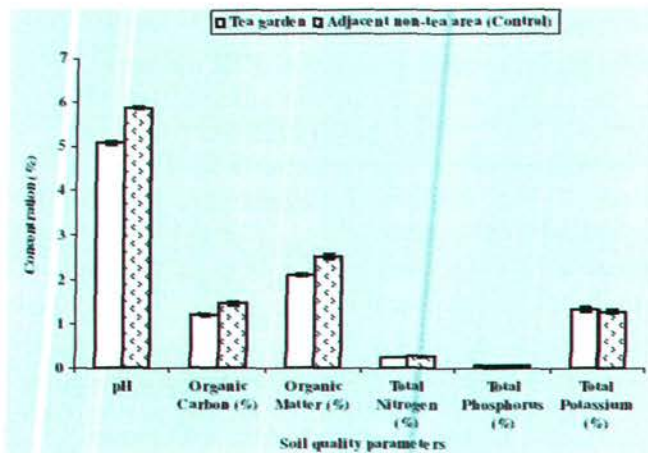
ness of the crop, rates of tea were fixed from Rs. 6 kg<sup>-1</sup> (41–45% fineness of crop) to Rs. 13 kg<sup>-1</sup> (>75% fineness of crop).<sup>11</sup> The production of made tea in 2007–2008 was 80,000 kg (UTDB, Almora). The best quality orthodox tea produced from the region was valued at Rs. 9,000 per kg and also attracted inquiries from buyers abroad. By the end of 2008–2009, a total of 573 ha area was planted under tea belonging to STGs and 3,57,552 mandays were generated (60% women) during the year.<sup>11</sup> Thus far approximately 700 ha land has been put under tea cultivation by UTDB, mostly in the small growers land in Uttarakhand (Fig. 1), and 218 ha area of plantations has been converted into organic tea (in Ghorakhal, Champawat and Nauti). At present, about 1500 labourers are deployed in tea gardens by the UTDB, of which women represent 60%, and so far 22 lakh man-days have been generated for the local people (www.utdb.uk.gov.in). A tea factory has also been established at Kausani in 2002 under PPP mode. Vision of Uttarakhand Government is to establish labour-intensive and eco-friendly tea plantations in 9,000 ha, so as to utilize fallow and cultivable but abandoned land in the region for the sustainable development of rural areas and to generate employment (www.utdb.gov.in; see Ref. 11). This venture has not only resulted in income and employment generation but also attempts to address the problem of soil erosion, along with the restoration of ever-growing wasteland, which otherwise provided poor quality foraging ground for the cattle, and was prone to soil erosion during monsoon.<sup>12</sup> In 2004, Joshi<sup>13</sup> reported that tea gardens in this area conserve more soil as compared to other land use; soil loss during monsoon was recorded to be 0.086 tons ha<sup>-1</sup> (tea gardens) to 10.98 tons ha<sup>-1</sup> (barren land).

## Ecological Considerations of Tea Cultivation in Uttarakhand

Raising of tea plantations is a land use activity that may have both positive and negative ecological and socio-economic impacts, more so in the sensitive ecosystems like the Himalayan mountains.<sup>14</sup> Tea plantation requires long-term investment by way of infilling, replanting, soil fertility management and weed control.<sup>15</sup> Fertigation is an important activity associated with intensive production of tea, and without this, the soil nutrients exhaust fast leading to mineral deficiencies in the plants, reduction in yield and ultimately resulting in dilapidated plantations.<sup>16,17</sup> In the tea gardens of Uttarakhand also, fertilizers such as ammonium sulphate, single super phosphate, murate of potash are used to raise soil fertility as per prescribed standards. Similarly, pesticides such as endosulphan, kalythene, phytolan, and thiodan are used to protect from the insects/fungal attacks and weeds. For example, the UTDB from 1995–1996 to 2002–2003 made a cumulative input of 627 kg fertilizer, 21 L insecticide, 11 L fungicide, and 13 L herbicides per ha of tea plantations (www.utdb.uk.gov.in). The reported use of pesticides containing sulphur, chlorine, and phosphate based chemicals is likely to result in accumulation of residue, if used indiscriminately.<sup>18</sup> Overuse of N fertilizer has been found to result in increased levels of nitrate-nitrogen in the ground and surface water.<sup>19</sup> Tea cultivation, on account of intensive cultural practices and inputs, therefore, needs to be considered also from the standpoint of ecological and socio-economic impacts, particularly on people, flora, fauna, soil, and water quality of the region. Observations were thus carried out by the authors during 2004–2005, and the results of the impact of tea cultivation on selected parameters are summarized as follows.

### (1) Soil Quality

To investigate the impact of tea cultivation on soil and water quality, three tea gardens, of different age (5–10 years), were selected in Kausani (altitude 1840 amsl; Distt: Bageshwar, Uttarakhand). Analysis of soil samples collected from selected tea gardens and adjacent non-tea growing areas (control) revealed that the mean concentration of soil organic carbon (SOC), organic matter and total nitrogen, as well as pH, were significantly lower ( $P < 0.05$ ) in the tea gardens as compared to the control sites. However, total phosphorus and total potassium were found to be slightly higher in the tea garden soils (Fig. 2).



**Figure 2.** Concentration of different soil quality parameters in selected tea gardens and adjacent non-tea areas of Kausani, Uttarakhand.

Due to regular weeding in the tea gardens minimal organic matter is left for decomposition, and thus the SOC remains low as compared to the adjacent non-tea areas (control) where sufficient organic matter is left behind to decompose. A lower concentration of major nutrients in tea garden soils over control results from regular plucking of tea leaves and weeding, which removes these nutrients from the system.<sup>20</sup> Various studies<sup>21</sup> have estimated removal of N (40 kg), P<sub>2</sub>O<sub>5</sub> (4 kg) and K<sub>2</sub>O (19 kg) per 1000 kg dry tea from the tea garden soils as a result of tea plucking. These nutrients need frequent replenishment through application of fertilizers. In the tea gardens of Uttarakhand, Verma<sup>17</sup> reported that 1000 kg of made tea produced removes major elements such as N (41.5 kg), K (21.5 kg), and P (3.3 kg), and has recommended N fertilization rates (9–12 kg ha<sup>-1</sup> per 100 kg of made tea) for the region.

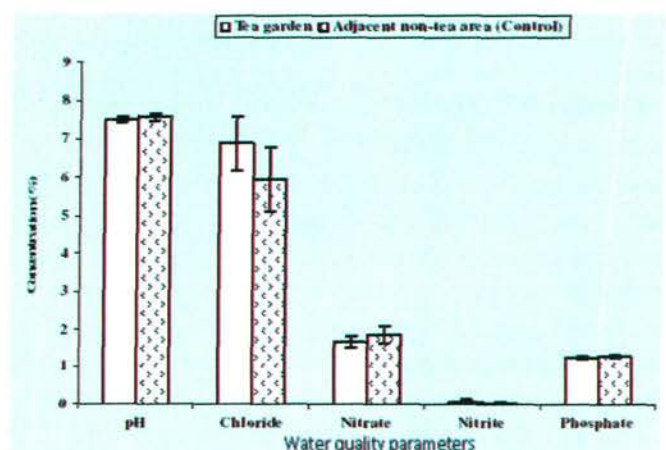
**(2) Water Quality**

The analysis of water quality of the three selected tea gardens and adjoining water sources (control sites) revealed that only nitrite was significantly higher ( $P < 0.05$ ) in the water draining from the tea gardens, whereas the other parameters such as pH, nitrate, chloride, phosphate, sulphate, and total hardness were almost the same; the differences, if any, were non-significant (Fig. 3). However, the seasonal (summer and rainy seasons) concentration of some of the elements (e.g., sulphate, arsenic, and iron) was more in the water draining from the tea gardens as compared to the control. The water quality of tea gardens recorded in this study was found within the quality norms of WHO and BIS, and comparable to earlier reports from the area (see Ref. 22; [http://cgwb.gov.in/District\\_Profile/Bageshwar.pdf](http://cgwb.gov.in/District_Profile/Bageshwar.pdf)).

**(3) Flora (and Fauna)**

One of the major concerns in the biodiversity-rich tropical landscapes is the impact of large-scale intensive agriculture, such as tea farming (as any other system of monoculture) on biodiversity.<sup>23</sup> For instance, introduction of tea in Sri Lanka in 1867 brought about, quite understandably, changes in the landscape of central mountain region.<sup>15</sup> In the tea gardens of Western Ghats, Kumara *et al.*<sup>24</sup> found exotic weeds such as *Eupatorium* sp., *Macarranga pellata*, etc. Invasion and multiplication of such weeds may cause adverse ecological effects on indigenous vegetation.<sup>25</sup> Biodiversity of arbuscular mycorrhizae (AM) fungi is also reported to be negatively affected with the use of chemicals in tea plantations of this area.<sup>26</sup> Apart from these above-mentioned observations, tea estates tend to support a fairly high diversity of amphibians.<sup>23</sup> The tree frog (*Rhacophorus pseudomalabaricus*) that was for the first time reported from the rainforests of the Indira Gandhi Wildlife Sanctuary (Anamallais) in 2000, was found to occur within the tea plantations.<sup>27</sup> Tea gardens in the Western Ghats also provide foraging grounds and movement corridors to wild mammals.<sup>24</sup>

To determine the changes in flora in the tea gardens *vis-à-vis* adjoining non-tea areas, eleven tea gardens spread over an area of 116 ha in the Kausani region (Uttarakhand) with tea plantations ranging from 5 to 10 years, were surveyed during summer, rainy, and winter seasons, and compared with the flora of adjoining non-tea areas (a list of plant species recorded during various seasons is available on request). Interactions with the locals as well as surveys revealed that a few weed species, *viz.*, *Ageratum conyzoides*, *Chrysanthellum americanum*, *C. crepidioides*, *Galinsoga parviflora*, *Lepidium sativum*,



**Figure 3.** Mean annual concentration of different quality parameters in water samples from selected tea gardens and adjacent non-tea areas of Kausani, Uttarakhand.

etc. were abundant in the tea gardens, but were uncommon in the native flora of the region.<sup>28</sup> These areas are also natural habitats of certain medicinal herbs, such as, *Centella asiatica*, *Mentha piperita*, *Valeriana wallichii*, and are also rich in bryophytic flora.<sup>29</sup> These weeds are non-palatable and therefore their spatial coverage may reduce the carrying capacity of grazers, and habitat ecology of medicinal plants may also change gradually; these may be kept in mind while considering expansion of tea gardens.

#### (4) Socio-economic considerations

As described earlier, tea cultivation in Uttarakhand is essentially a STG activity. The UTDB has taken up uncultivable farmlands, community wastelands, and abandoned tea gardens on lease and employed local labour in the tea gardens to perform different operations. The average land holding in the region is 0.8 ha, which is distributed into several parcels of land. Therefore, UTDB has tried functional consolidation of the unutilized land to raise tea gardens. Household survey of 168 STGs done in the region, under the management of UTDB, revealed that about 70% of the land owners cultivate tea themselves, the rest 30% employ waged labour (mostly absentee landlords and get lease rent @ Rs. 1000–1500 ha<sup>-1</sup> yr<sup>-1</sup> depending upon the quality of land). This also avoids the risk of encroachment by others. The participation of women in tea cultivation in their own land is nearly 50%; however, among the waged labourers, 68% were women. Thus, tea cultivation has created significant employment opportunities for women in the studied villages that has helped them to improve their purchasing power and social respect.

Among the surveyed households limited (15%) respondents showed willingness to offer further 17 ha land (13.8 ha agricultural land, 3.2 ha uncultivable wasteland) in future for tea cultivation, but a majority (44% people) wanted to retain the remaining superior farmland for food crop cultivation. Rest of the respondents gave reasons (for not offering their land for tea cultivation) such as, non-availability of consolidated land, lack of employment generation as per their expectations, or unavailability of family members for tea cultivation, etc. It is clear that despite the efforts of the Government for spread of tea plantations, the STGs prefer to retain a certain portion of their holdings for cultivation of food crops, and are willing to put only uncultivable and inferior land under tea—a good strategy to ensure food security. Further, it is also important to mention that the introduction of tea cultivation has caused a marginal shift

from agriculture and livestock husbandry-based livelihood to cash crop-based livelihood (tea cultivation). This shift of land use (coupled with other factors) also results in reduced availability of fodder and household labour that in turn causes in reduction in livestock size (by 37%) among the studied STGs (Fig. 4). Before the introduction of tea (or for that matter any other plantations, e.g., orchards), agricultural crop residue and fodder produced in the marginal holdings was used for the livestock in the surveyed households.

Our primary observations on output: input (O/I) ratio of tea cultivation in the studied area indicate that the O/I ratio (1.86) becomes remunerative in the 5th year onwards of tea plantation. This needs to be investigated further to take appropriate measures so as to make tea plantations sufficiently attractive right from the initial years. In this regard, intercropping of tea with legumes (e.g., *Crotalaria* spp., a pulse, etc.) may be an option that would enhance soil fertility through alley cropping and nitrogen fixation, and also yield produce for the self-consumption of farmers.<sup>30</sup> Ghosh *et al.*<sup>31</sup> (2008) have developed some tea-crop models at research farm of IIT, Kharagpur, that integrate tea with nurse trees (*Albizia* spp., sandal wood), fruit trees (guava, gooseberry) and turmeric and zinger that help generate additional income ranging from 54–115% over the income from tea alone. Nurse trees (e.g., *Albizia lebbek*, *Grevillea robusta*, etc.) in the tea gardens will yield some fuel wood in the long run.<sup>32</sup> In Uttarakhand, both native and exotic trees have been planted/maintained as nurse trees in the tea gardens. Thus, apart from tea as the main produce of tea gardens, there exists a good scope for obtaining other products that supplement tea production in this region. Tea gardens should thus be regarded as an agro-ecosystem where tea is the principal crop, and nurse trees, other

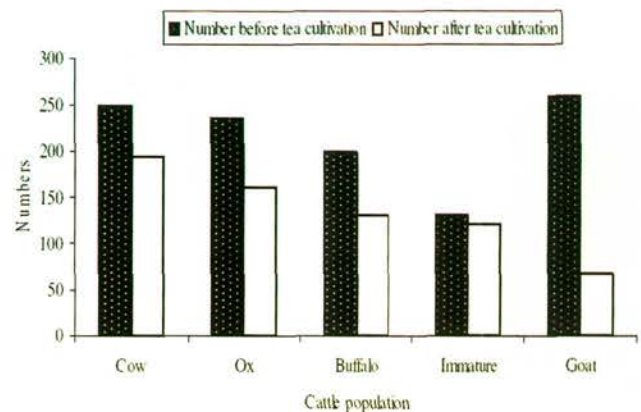


Figure 4. Tea cultivation vis-à-vis livestock population and composition in the surveyed households ( $n = 155$ ).

intercrops as well as vegetation on terrace bunds could be judiciously chosen to cater to fuelwood, fodder, NTFPs and other needs of the STGs. The views of locals on the impact of tea cultivation have been summarized in Table 1.

**Difficulties Faced by the STGs**

Tea is a labour-intensive plantation crop; around 65% of the cost of production is incurred on labour. On an average tea plantations take at least 3 years to start leaf production and 10 years to become sufficiently remunerative. During this period, farmers get work for a few months only for leaf plucking between March and November. The daily wage is on the basis of 8 hrs work and a worker should collect 12 kg leaves (<http://www.downtoearth.org.in>).<sup>33</sup> Out of the 168 STGs surveyed, 115 individuals responded on problems associated with tea farming and also offered several suggestions for improvement. The majority respondents (98%) opined that the wages and lease rent for the land should be increased. Most of the smallholders see this activity as a means of income and employment generation; most farmers were in favour of tea plantations and acknowledged that orchard development in the land presently put under tea cultivation has not been successful in the past. Need for better management of tea gardens, judicious use of chemicals and fertilizers, capacity building of tea farmers on appropriate techniques of tea cultivation, provision of facilities to labourers (such as medical, insurance, leave), and need for fencing the tea gardens were also concerns raised by many respondents (~ 60%) of the surveyed STGs.

It should also be pointed out that Uttarakhand Land

Reform Act, 2003, does not permit sale and large scale leasing of farmland to private entities from outside the state (leasing limited to 0.004 ha or 400 m<sup>2</sup>). This together with small holdings of farmers is a bottleneck for expansion of tea industry/plantation area (<http://www.downtoearth.org.in>).<sup>33</sup> It is also notable that as many as 15 different brands of tea are sold in the local markets, and the locally produced Uttarakhand Tea (Nandadevi) has still to carve a market of its own. It appears that the other brands available in attractive packing with good liquor quality and odour, lower cost also compete with the local tea.

**Some Agro-meteorological Considerations**

The concept of eco-friendly management of tea plantations has been an emerging concern for sustainability of this land management practice.<sup>34</sup> Now that the importance of tea has been realized in Uttarakhand, it is important that good, long-term planning along with proper R&D back-up should be available for sustaining the tea industry. As per Tea Research Association, Tocklai (<http://www.tocklai.net>) tea requires a moderately warm and humid climate and grows best on well-drained fertile acidic soils on high lands. In Uttarakhand, tea plantations are raised between 1400 and 1700 m asl; majority areas contain soft brown, porous soil having silica and mica, are alkaline in reaction (pH 6.9) and low in moisture.<sup>29</sup> In the study area, Joshi<sup>13</sup> has reported soil physico-chemical characteristics in various land uses; pH (range = 6.16–6.88), organic matter (1.64–2.82%), and total N (0.098–0.167%), and values for tea garden soil were recorded by us (pH = 6.16, OM = 2.05% and total N = 0.167%) indi-

**Table 1: A Summary of Perceived Impact of Tea Cultivation (based on the queries with 115 STGs)**

S. No.	Impacts	No. of Responses	S. No.	Impacts	No. of Responses
1.	Solution to employment	111 (+)	8.	Loss of biodiversity	81 (-)
2.	Improved use of wasteland	110 (+)	9.	Risk of pollution of water sources due to chemical fertilizers/ biocides	78 (-)
3.	Aesthetic appeal of the landscape	110 (+)	10.	Loss of fertile soil through drainage of runoff water from tea gardens	74 (-)
4.	Prevention of soil erosion	107 (+)	11.	Reduced livestock wealth	55 (-)
5.	Enhancement of land quality	101 (+)	12.	Danger of snakes/ wild animals	3 (-)
6.	Check on out-migration	55 (+)	13.	Reduction in quality of grass around tea gardens	3 (-)
7.	Enhanced social respect	9 (+)			

(+) Seen as a beneficial activity; (-) Perceived to have negative influence.

cate that soil is poor in respect of fertility. The minimum and maximum temperature ranges from 4–36°C, and the relative humidity varies between 40–80%, highest in July and lowest in January.<sup>29</sup> Average rainfall during November–June (other than the monsoon season, June–September) is inconsistent and less than one-fourth of the annual rainfall of about 1500 mm, which is less than loss due to evapotranspiration resulting in soil moisture deficit that affects tea growth, in spite of high monsoon rainfall. Further, more than the total amount, the distribution of rainfall throughout the season matters a lot for sustained high yield of tea. The monthly and annual rainfall data of Kausani for the period 1997–2002 shows the annual average rainfall of 1331.4 mm ([http://cgwb.gov.in/District\\_Profile/Uttarakhand/Bageshwar](http://cgwb.gov.in/District_Profile/Uttarakhand/Bageshwar)). In 2002, annual rainfall at Kausani was recorded 1057 mm (87 rainy days) and during the month of March and May (when new leafing occurs in tea) the rainfall was < 5 mm. Thus, adequate rainfall during winter and early spring is crucial for growth and yield, and supplementary soil moisture needs to be provided to tea plantations to support new leaf crop. Further, soil depth on hill slopes is low and young tea plants are liable to suffer from moisture deficit due to low moisture storage capacity of soil. Joshi *et al.*<sup>35</sup> screened six tea clones growing in the tea plantations of Uttarakhand for various eco-physiological parameters. It was found that in the hot and dry valleys the thermotolerant clones such as, B/5/63 and B/6/61 showed high photosynthesis and B/6/61 clone performed better in areas where temperature fluctuations are very high.<sup>36</sup> Thus, selection of suitable clones for agroclimatically diverse areas is essential for successful tea plantations, and that  $F_v/F_m$  ratio, measured easily, can be used as a tool for screening of clones suitable for various agroclimatic zones.<sup>35</sup>

### Suggestions for Improvement of Tea Industry in Uttarakhand

It is apparent that the sustainability of tea depends on a variety of factors; some suggestions, based on this study and review of existing knowledge on tea cultivation, particularly in Uttarakhand, are as follows.

1. Tea as crop requires specific climate, rainfall pattern, topography, soil physico-chemical factors, and specific silvicultural operations. Baseline information on these aspects, in respect of this region needs to be strengthened; micro-irrigation would seem essential for establishment of young tea plants in the low rainfall areas, along with water harvesting and *in-situ* moisture conservation measures.
2. Plantations should be developed as an integrated agro-ecosystem that also cater to other needs of the STGs. Planting of insect-pest repellent trees (*viz.*, *Melia azedarach*, *Adathoda vesica*, lemon grass and guatemala grass,<sup>37</sup> and shade trees (fuelwood, edibles, nectar for pollinators, *etc.*) would enhance the overall returns from tea ecosystems.
3. Tea under unshaded conditions is prone to tea mosquito bug, red spider mites and thrips and thus plant based pesticides and microbial biocides need to be adopted.<sup>38</sup> A total of 58 arthropods infesting tea plants have been reported from tea-growing regions of Uttarakhand.<sup>39</sup>
4. Plantations with high yielding and good quality clones will help in mitigating the problem of yield and quality.<sup>35,40,41</sup> The use of growth promoting and soil mineral solubilizing microbial biofertilizers,<sup>42</sup> AM fungi<sup>43</sup>, and vermiculture needs to be promoted.
5. Organic tea is considered a panacea for STGs who practice low-input agriculture. Certification of organic tea needs to be taken up on priority.<sup>44</sup>
6. As tea cultivation in the region is mostly STGs type, training of the growers and staff of the UTDB by an expert group will certainly improve tea industry.

### Conclusions

In conclusion, Uttarakhand is poised to witness the revival of tea industry. As an important source of revenue, tea gardens will again dot the landscape of this region, providing gainful employment to the locals, especially women.<sup>45</sup> However, a number of points that have emerged from this study also need to be considered in planning for further expansion of tea plantations in this region.

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