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Ecological needs for a sustainable tea production in Darjeeling, India

Hans-Joachim Fuchs

The paper aims to present fundamentals and principals of ecological tea cultivation in a very brief manner. The findings are valid for the growing conditions in the Darjeeling Hill Country. Different kinds of erosion in tea fields will be explained. The evaluation of various agricultural practices in tea cultivation was undertaken and proved in an existing tea plantation. Numerous realizable ecological innovations were discussed and introduced. Sustainable tea cultivation in Darjeeling has only a chance, if long-term ecological measures are implemented.

1 Introduction

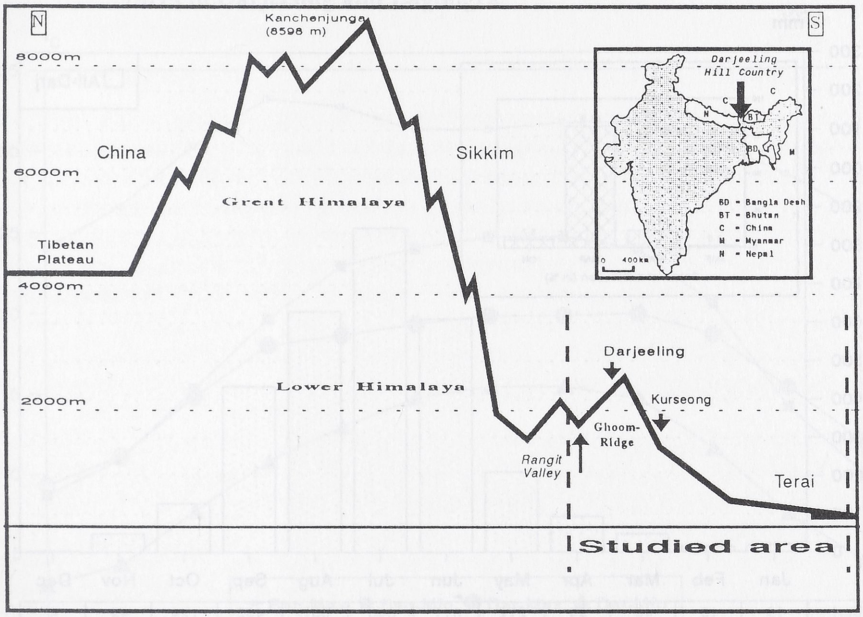
Darjeeling tea from the West Bengalian hill-district in Northeast India is one of the finest teas in the world. The 66 tea plantations (150 to 300 ha average size) are located on the steep slopes of the Lower Himalaya in altitudes ranging from 300 to 2,100 m a.s.l. There are no tea smallholders. Tea planting in Darjeeling started over 150 years ago in 1835. The total hectarage of land under tea cultivation in the Darjeeling District amounts to 21,000 ha only (1996). 75% of the tea bushes are China seedlings or China hybrids characterized by small leaf sizes. 20% of the existing tea bushes belong to the larger sized Assam hybrid.

The average yield of Darjeeling tea plantations is only 650 kg/ha/year made tea. Only 5% of the tea land is planted with clonal tea bushes. On the one hand, such vegetatively propagated tea plants are very high yielding (over 2,000 kg/ha/year), but on the other hand very often susceptible to various pests and diseases. Also the taste and flavour is different from those teas which are manufactuered out of leaves harvested from China seedling tea bushes. Therefore, the Darjeeling tea planters are very conservative in uprooting the over-aged tea bushes and in undertaking large-scale replanting activities.

2 Topography

Darjeeling, the northernmost district of West Bengal is situated between 26° and 27° north latitude and between 88° and 89° east longitude. The Darjeeling Hill Country is a southern portion of the outlying hills of the East Himalaya (Fig. 1).

Fig. 1: North-south profile through the Himalaya at 88° E

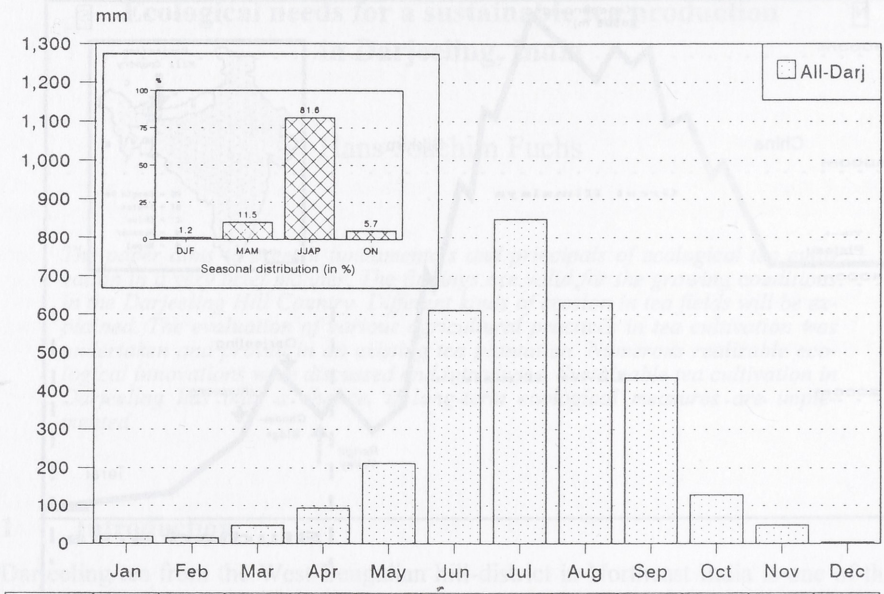


The hills abruptly rise from the Terai plains with an increasing elevation northwards, reaching its maximum elevation on top of the east-west running Ghoom-Ridge, amounting to 2,500 m a.s.l. The deep Rangit-Valley separates Darjeeling from Sikkim. Further north, in the State of Sikkim, the central Himalayan axis passes east-west through the Kanchenjunga, the third highest peak of the world. The Darjeeling Hill Country is characterized of a mosaic of meso-topographic units consisting of a confusing labyrinth of ridges and valleys. From the main east-west running Ghoom-Ridge, several spurs and valleys originate and follow the slopes to the south towards the Terai lowland as well as to the north towards the Rangit River.

3 Climate

The climatic data (1961-1990) were collected from 13 tea plantations and 3 observatories of the India Meteorological Department scattered in the studied area of the Darjeeling Hill Country. The mean annual total for the 16 stations (All-Darjeeling) amounts to 3,095 mm. Taking the annual All-Darjeeling variation of precipitation into consideration, a pronounced seasonality can be observed (Fig. 2). July is the wettest month with 848 mm rainfall which are 27.4% of the mean annual total. Values below 20 mm per month are recorded from December to February.

Fig. 2: All-Darjeeling annual variation of precipitation



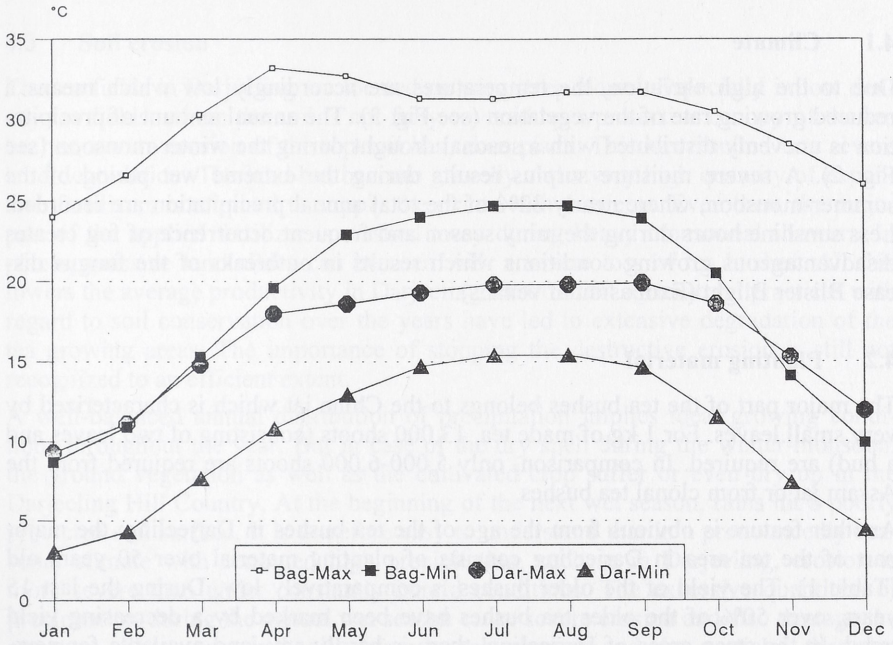
All-Darj	19	15	48	94	212	611	848	631	435	129	49	4
All-Darj-%	0.6	0.5	1.6	3	6.8	19.7	27.4	20.4	14	4.2	1.6	0.1

Based on the variations of precipitation, temperature and wind, the year in Northeast India is commonly divided into 4 distinct seasons:

1. Winter monsoon (December-February): the seasonal amount of precipitation is only 38 mm or 1.2% of the annual mean.
2. Pre-monsoon (March-May): is transitional between the dry winter and wet summer, and is characterized by a rapid rise of the mean temperature. Thundershowers with hail-storms frequently occur. The region receives 354 mm of precipitation (11.5%).
3. Summer-monsoon (June-September): the average rainfall amounts to 2,525 mm or 81.6% of the annual total. During this period, the warm and moist air flowing from the Bay of Bengal are forced to rise against the east-west running ridges of the Himalaya, causing heavy orographical rainfall, especially on the southern exposed slopes.
4. Post-monsoon (October-November): retreat of the summer-monsoon, sesonal rainfall amounts to 178 mm (5.7%).

To give a brief introduction to the thermal situation, the mean monthly maximum and minimum temperatures of Darjeeling (2,128 m a.s.l.) and Bagdogra (131 m a.s.l.) were taken into consideration (Fig. 3).

Fig. 3: Annual variation of the mean maximum and minimum temperatures in Darjeeling and Bagdogra



Throughout the year, the hill region is naturally cooler. The curve of the mean maximum temperature in Bagdogra is typical for a monsoon climate, having the highest value in April during the pre-monsoon, which is characterized by cloudless sky and intensive insolation. With the onset of the summer-monsoon, the sky becomes more cloudy lowering the mean maximum temperature. The minimum values are less effected. The diurnal range of temperature is highest during the winter season amounting to 20-25° C and lowest during the summer-monsoon (7-8°C).

The diurnal range of temperature for the Darjeeling hill station is comparatively low, amounting to only 5-8° C throughout the year. The hills mostly remain covered by clouds and afternoon fog occur from April onwards, decreasing the sunshine duration. This and the high wind velocity at higher elevations lowers the daily amplitude. Maximum temperatures are reached during the summer-monsoon (nearly 20° C).

4 Reasons for the low tea productivity in Darjeeling

The average annual yield of only 650 kg/ha is comparatively low. The neighbouring Assam Valley, the lowland tea growing area (180,000 ha) in Northeast India, is characterized by annual tea yields of 1,600-2,000 kg/ha made tea. In order to evaluate the economic and ecological needs for a sustainable and vital tea production of

the Darjeeling Hill Country, it is necessary to analyze and to discuss the possible reasons for such a low productivity.

4.1 Climate

Due to the high elevation, the temperatures are accordingly low which means a reduced growing rate of the vegetation (see Fig. 3). The annual amount of precipitation is unevenly distributed with a seaonal drought during the winter-monsoon (see Fig. 2). A severe moisture surplus results during the extreme wet period of the summer-monsoon, where nearly 82% of the total annual precipitation are recorded. Less sunshine hours during the rainy season and frequent occurrence of fog creates disadvantageous growing conditions which results in outbreaks of the fungus disease Blister Blight (Exobasidium vexans).

4.2 Planting material

The major part of the tea bushes belongs to the China jat which is characterized by very small leaves. For 1 kg of made tea, 13,000 shoots (consisting of two leaves and a bud) are required. In comparison, only 5,000-6,000 shoots are reqiured from the Assam jat or from clonal tea bushes.

Another feature is obvious from the age of the tea bushes in Darjeeling: the major part of the tea area in Darjeeling consists of planting material over 50 years old (Table 1). The yield of the older bushes is comparatively low. During the last 15 years, over 50% of the older tea bushes have been marked by a decreasing yield trend. In the steep areas of Darjeeling, there is hardly any land available for new-clearings. Due to severe deforestation which has taken place over the last decades, the soils are degraded and therefore not suitable for tea cultivation. Replanting of tea in the higher altitudes is very difficult and takes a long time.

Table 1: Age and distribution of the tea bushes in Darjeeling (India Tea Board, 1995)

Age	> 5	5-10	11-20	21-30	31-40	41-50	> 50
Area	2.3	1.6	4.5	4.1	2.6	5.3	79.6

A tea plant in the Darjeeling Hill Country takes about 5-6 years to reach the economic stage of plucking, whereas in the lowlands (for example in Assam) only 2-3 years are necessary.

In Darjeeling, the planters do not undertake large replanting programmes and the old tea bushes remain in the fields. The oldest tea bushes in Darjeeling are 130 years old and still producing pluckable shoots. The quality of black tea made from these bushes is extremely high. Therefore, everybody wants to have such bushes in the plantation. On the other hand, nobody knows so far, how much longer these tea bushes can be plucked. Approximately every 30 years, a rejunvenating prune is

undertaken, which means that the bushes are totally pruned; only 10-20 cm of the stem remain.

4.3 Soil erosion

The tea fields in Darjeeling are located on very steep slopes. Especially in low density tea fields, where the soil is not fully covered by a protective canopy of the tea bushes, severe erosion of the top-soil has taken place. This has resulted in a severe land degradation. The land has become gravelly and a very high quantity of expensive fertilizers is required to supply the plants with nutrients. Even then, the major part of the applied fertilizer is washed away during heavy monsoonal showers. In places, massive land slides can be seen with a severe loss of tea bushes. All this lowers the average productivity in Darjeeling. Insufficient agricultural practices with regard to soil conservation over the years have led to extensive degradation of the tea growing areas. The importance of stopping the destructive erosion is still not recognized to an efficient extent.

A well-balanced annual distribution of precipitation implies ideal growing conditions throughout the year. But in case of the dry spell during the winter-monsoon, the ground vegetation as well as the cultivated crop suffer or even dry up in the Darjeeling Hill Country. At the beginning of the next wet season, rains hit a poorly protected soil surface. It is therefore easy to understand that in a pronouncedly seasonal climate with centrated high precipitation, such as in Darjeeling, erosion is more severe than under constantly humid conditions. The excessive quantities of precipitation during the annual wet season cause severe erosion and also damage the structure of the uncovered soil surface by releasing silt and clay particles, that clog the pores.

The majority of the total area under tea in Darjeeling is planted with China seedling tea bushes which are marked by an inherent poor canopy. The wide spacing (0.9m x 0.9m or 1.2m x 0.9m), and the failure of a regular replacement (infilling) of dead bushes are some of the factors that have contributed to poor soil cover in mature tea fields. Due to the genetic variability the China seedling bushes do not show uniform growth and where the crop canopy is poor, the spaces between the rows become channels for the destructive surface run-off (gully-erosion).

There is, in addition, the unavoidable soil exposition for a period of four to six months once in five years, when most of the canopy is removed by pruning. During this period the exposed soil gets easily washed off. In many seedling tea fields there are no contour drains at all. If lateral drains are built, they are not planted with low vegetation or stone paved. Therefore they are often transformed into ravines and gullies, in which a large amount of soil is washed away from the side walls, leaving the tea roots exposed. Uncovered soil in patchy tea fields as well as the gradual deepening of gullies due to continuous erosion lead to a lowering of the water-table. This is combined by a consequent harmful effect regarding the moisture status of the surface layers of the soil, upon which the tea crop depends during dry period of the winter-monsoon. This resulted in the alarming fact that the crop at present is more susceptible to droughts.

4.4 Weeding

The surprising fact is, that the colonial way of running estates, especially the clean-weeding, is still practised in a large number of estates. Most of the estates were kept completely weed-free over decades, because a clean weeded estate was the hallmark of 'good management' (Chakravarty 1982). Consequently all efforts were made to remove every blade of non-tea vegetation by the use of weed-scrapers. The weeds were cut at ground level by vigorously scraping the soil. But this method destroyed the structure of the soil, and what was left on the ground was a layer of loose top-soil, which was easily washed away by heavy rains. Most of the present plantation managers have learned under the former British owners, and therefore, the colonial way of plantation management is still practised to a great extent.

The exposed surface after weeding dries up very soon during a drought, which means, an increased soil temperature and high evaporation rate resulting in water stress for the tea plants. In this manner the soil forms a hard pan and decreases the infiltration and percolation of the rain water during the rainy season. In addition scraping will not only prepare a suitable bed for weeds to grow but also stimulate dormant seeds to germinate.Weeding is currently done at 1-3 months intervals.

4.5 Bush density

The above-mentioned reasons in 2.3 and 2.4 are key-factors for the frequent occurrence of very patchy tea fields in the Darjeeling Hill Country which are and marked by a comparatively low bush density. The average number of bushes/ha in Darjeeling is around 7,000, whereas the bush density in the Assam lowland is over 12,000 bushes per ha. This is one of the major reasons for the comparatively low yield in the Darjeeling tea growing region.

4.6 Labour intensive harvesting

In Darjeeling, around 13,000 tea shoots are needed to produce 1 kg black tea. The weight of one Darjeeling-tea-shoot is much less compared to one Assam-tea-shoot which means a very labour intensive plucking process. During the rush period with heavy flushing tea (May, June, July), the availabilty of tea pluckers is a severe problem in Darjeeling. This results in delayed plucking rounds which has a direct impact on productivity. To find labourers for other field work is not a problem during that period, but plucking of tea requires experience and cannot be done by non-trained labourers.

5 Possible Solution: Ecofarming

In order to increase and to optimize productivity, long term measures have to be implemented. Ecofarming on a plantation scale is the only way out. Only an ecologically well-balanced tea cultivation will help to overcome the problem of soil degradation in steep areas, such as in the Darjeeling Hill Country. A severe problem in the hills is the massive deforestation around the tea plantations by the workers.

They need fuelwood for their houses which is not supplied in an organized manner by the plantation management. The deforestation results in inundations of the major rivers. Not enough attention so far has been given to the severe problem of soil erosion, which means the need to reduce water and soil losses caused by excessive rainfall run-off.

Tea land, especially in the steep areas of Darjeeling, is losing productivity because valuable top-soil is being washed or blown away much faster than natural rebuilding and rehabilitation processes can take place. Reducing the topsoil means reducing plants' access to essential soil nutrients and water. Therefore, the agricultural practices in the tea sector should be innovated and modified.

In order to reach an ecologically well-balanced and sustainable tea cultivation, the following soil conservation measures and inputs are of utmost importance. All following ecological measures are successfully implemented in the Makaibari Tea Estate, the pilot plantation of the ongoing research project. Makaibari is located close to the town Kurseong, on the southern slope of the Ghoom-Ridge in 1,100 to 1,400 m a.s.l. The area under tea amounts 273 ha.

6 Selected ecofarming measures for tea plantations

6.1 Education campaign

An education campaign is the first step to erosion control. In such a campaign age-old customs may have to be changed. Practical courses should be organized in the tea estates, showing the effects of disadvantageous ecological factors on the cultivated land. In particular field officers and labourers have to be well trained, because they are out in the fields every day and must understand and realize the effects of various agricultural practices on the ecology of a plantation. Otherwise the implementation of modified or even new practices will be very difficult.

6.2 Mulching

Mulching means covering the unprotected soil surface with a layer of organic material. The mulch material, in form of fast growing grass species, should be planted in the lowlands as well in the plantation itself. Mulching should be started in patchy tea fields in order to cover the exposed soil parts between the tea bushes. This reduces the evaporation of the soil and shields the soil surface from sun, wind, and from the impact of raindrops. Like a sponge, a mulch cover can quickly absorb plenty of water, which then passes slowly into the soil. Mulching avoids high soil temperatures and provides protection against surface and splash erosion as well as the formation of an unpermeable soil crust. Soil organisms, such as bacteria, fungi, and earthworms quickly multiply and start decomposition within the mulch and the upper soil layer. The activities of the organisms cause favourable changes in the structure of the upper soil layer, thereby improving aeration and the water absorbing and water-holding capacity of the soil. In addition mulching ideally prevents the growth of weeds. The increased organic matter in the soil is an excellent stabilizer,

preventing large crop fluctuation by ensuring good tilth, stable moisture relationships, retention of valuable nutritive elements, and a conservation of the capital supply of Nitrogen, the most expensive and most easily lost of all crop requirements.

The tea bushes in every field are frequently pruned or skiffed. During the period of recovery, the soil is unprotected, which causes massive erosion processes. The recovery of pruned tea bushes will be much faster, if the plants were able to utilize the nutrients released from the mineralization of mulch for their growth. Therefore, it is absolutely necessary that the natural mulch, such as prunings itself, leaf litter from tea bushes and weeds, remains undisturbed on the soil surface. Normally, the workers collect these materials and use them as fuelwood. In this layer almost all nutrients required by the plants are made available and can be absorbed by the tea plants. The extra costs, resulting from chopping the prunings and retaining them in the fields, are more than compensated due a to shorter duration of the unproductive stage of the tea plants. 25-35 tonnes/ha pruned organic material contain about 250 kg/ha of Nitrogen, 125 kg/ha of Phosphorus and 180 kg/ha of Potassium. If this amount of pruned material get incorporated into the soil, the released nutrients will benefit the soil and fewer quantities of artifical fertilizer will have to be applied.

To ensure that the prunings as organic material remain in the tea fields, fuelwood has to be provided for the worker families. For the Darjeeling region, this is a very expensive and difficult task. The plantation management of the Makaibari Tea Garden has constructed 13 biogas plants for the workers so far. Cattle was also given to the workers. Due to this system, the respective workers are independent regarding fuelwood which is a valuable insurance that the prunings remain as organic material in the tea fields.

It is essential to cover the uncovered soil in tea estates, especially in patchy seedling tea fields and after pruning operations. Guatemala grass (Tripsacum laxum) as well as Mana grass (Cymbopogon confertiflorus) are the most suitable grass species for thatching purposes. Unproductive tea lands can be converted into permanent thatch banks in order to have sufficient thatch material in stock, when it is needed. After lopping the grass to ground level, they will shoot up again and provide new thatch material. The layer of mulch on the soil surface must have a thickness of at least 5-10 cm.

The bundles of grass loppings should be placed crosswise on the soil surface, forming a netting system, which protects the mulch material against wash-off. In addition wooden pegs (about 20-30 cm in length) can be prepared and driven into the ground in lines of 10-15 cm depth along the contour close to the individual tea plant. Due to this system the mulch will be held in place. Especially after heavy showers, a gang of labourers should check the state of the mulch layer and do the necessary repairs.

6.3 Cover crops

Instead of the mulching of the uncovered soil in the patchy tea fields, the planting of suitable grasses as live-mulch (cover crops) is also an effective measure to minimize soil erosion, particularly in the steep to very steep tea fields. This method is

time-consuming, but temporary labourers are available in the neighbouring villages. Once established, the cover crops provide a long-term protection against soil erosion. Compared to mulching, cover crops have similar advantages regarding soil conservation. The following species are suitable in the Darjeeling Hill Country:

- African Love grass (Eragrostis curvula) is suitable for all elevations. Besides protecting the soil against soil erosion, this grass also reduces soil populations of root-lesioning nematodes (Pratylenchus loosi).
- Crotalaria stricta and Sesbenia cinerescens are shrubs which should be trimmed at a height of 0.9 m from ground level. They can be used as ground covers in wind-swept areas in order to reduce the velocity of the surface winds.
- Mana grass is a suitable grass in order to minimize soil erosion in the new clearings as well as in the mature tea fields. It should periodically be slashed to ground level and the loppings should be used to thatch the remaining uncovered soil in the fields or can be used as fodder (many worker families have their own cattle).
- Vetiver Grass (Vetiveria zizanioides) as cover crop has shown very good results. It is a perennial grass and propagated by root divisions. The plant reaches a height of 0.5-1.5 m establishing 75 cm long and 8 mm wide leaves. The grass is able to withstand extreme droughts. It tolerates a wide range of the pH value and temperatures up to -9° C and + 45° C, and is very easy to establish. The grass does not produce seeds which germinate under normal field conditions. Vetiver grass has a strong root system and shows a resistance to most diseases. The sharp leaves and aromatic roots avoid snakes.
- Desmodium heterophyllum or Drymaria cordata would also be ideal, because these species prevent soil erosion and are the least harmful of all the weeds, since they dry up under drought conditions and therefore do not compete for moisture. They develop quickly during the rainy period and again provide protection against splash erosion.

The recommended cover crops should be planted in between the tea rows to form an effective live-barrier against soil erosion. If this system is implemented, the tea field will consist of alternating rows of tea bushes and ground covers. The uncovered soil between the respective rows can be thatched with the loppings of the periodically slashed cover crops. Of course, the maintenance of this system is costly, but its implementation will drastically reduce the weeding costs. The saved money could be used for proper ground cover management. Temporary labourers are available in the neighbouring villages.

Especially in patchy tea fields the vacant places can be thatched with mulch, as it was already mentioned, or planted with cover crops, such as Mana grass or Eragrostis. The soil reconditioning brought by these grasses will favour the establishment of infillings. Cover crops also suppress weed growth in mature tea fields, which will reduce the weeding costs. The saved funds can be used for the periodical slashing and maintenance of cover crops.

6.4 Weeding

The manner of weeding practised on many tea estates is a very destructive process and also one of the most expensive items in the costs of producing tea. It is an accepted fact that preventing weed growth will definitely be cheaper than controlling weeds after they have established themselves. The tea bush itself is the most efficient weed killer in case of a higher bush density and correct bush management. The bare plots in tea fields have to be mulched with loppings from Guatemala or Mana grass or planted with cover crops, such as Eragrostis and Mana grass, and thereafter to be infilled with tea.

Manual weeding has to be done without the usage of scrapers by hand-pulling or using less harmful implements, such as a sharp spear, that helps to dig out deep-rooted weeds. It is most essential to evolve a careful, selective weed management programme, entailing a selective removal of aggressive weeds without inducing any form of erosion. An important approach in such a programme will include the planting of cover crops after the pulling out of the deep-rooted weeds. Low-growing weeds species should be allowed to grow because competition for nutrients and moisture are minimal. During dry weather conditions they dry up and quickly develop with the onset of the rainy period.

Chemical weeding in a plantation is a cheap way of controlling weeds, but it causes residual effects on the ecosystem. Grammaxone is widely used for routine chemical weed control in Darjeeling and applied directly to the weeds with a sprayer. But the problem still is to find herbicides that are easy to apply and that act selectively, destroying only the weeds which affect the tea bushes. It appears, that up to now weed killers that are strictly selective have not be developed yet. Most herbicides can also affect the crop adversely, especially when higher doses are applied, which are necessary to kill persistent weeds. Special equipment is needed and the labourers have to be thoroughly trained on the subject, before they can be allowed to work with weed killers. There is always the danger that the cultivated crop is damaged by an overdose or careless application, which results in twisted or deformed shoots on the tea bushes. Under the present conditions the use of herbicides cannot be recommended in the entire agricultural sector in Darjeeling.

The best control of weeds is a dense vegetation cover, either by tea bushes themselves or by the planting of cover crops in between the tea rows or in the patches of mature tea fields. Mulching of uncovered soil in tea fields is also favourable or even the toleration of low-growing weeds. In addition selective weeding by hand-pulling without the use of scrapers has to be ensured. Chemical weeding has to be reduced as much as possible due to various disadvantageous effects on the ecosystem.

6.5 Slope Stabilization

6.5.1 Contour Drains

The most effective and economical soil conservation measure in steep tea lands is the contour 'lock and spill' type drain. This drain should be connected to a stone-terraced leader drain, designed to divert the surface run-off into stable water-

ways without creating new gullies. The lateral drain should have a minimum width of 0.6m and a depth of 0.5m. The soil, excavated from the drain, should be heaped on the upper as well as lower edge of the drain to form a small bund, leaving a 20 cm berm between the bund and the edge of the drain. To protect the upper and lower lip of the drain, a suitable grass, such a Eragrostis curvula, has to be planted in a row at a spacing of 5 cm, forming a live-barrier.

The distance between the contour drains will depend on the steepness of the terrain. In the very steep (>60%) areas the spacing between two drains should be 8-10 m; in the steep (>30-60%) areas about 13-15 m; in the moderately steep areas (>16-30%) areas about 18-20 m; in the hilly (>8-16%) areas about 25-30 m, and in the undulated (>2-8%) areas about 40-50 m. The accumulated silt in the lateral drains has to be removed regularly (every year) and the soil should be distributed in areas above the drain.

6.5.2 Construction of Contour Bunds

Another very efficient method of slope stabilization is the construction of stone bunds, which protect the soil from being washed downslope. Collected stones can function as slope stabilizator. Depending on the availability of such stones, the construction of stone bunds is highly suitable. These are low walls of about 10-20 cm height along the contours in between the tea rows. The contour bunds will serve as barriers against soil erosion.

In case of a poor availability of stones, grass bunds out of Guatemala or Mana loppings can also be constructed. The grass bundles should be aligned on the contours at a height of 20-30 cm and should be kept in place with thongs of 'lianas' or anchored with wooden pegs on either side of the bund. The peg depth and number depends on the soil. In gravelly and sandy soils wooden pegs do not penetrate deeply enough, so the bunds need to be pegged to a depth of 20-30 cm every 50 cm. On finer-textured soils, peg penetration is easier and depths of 40-50 cm are achievable, with a peg spacing up to 1 m.

If funds for the latter systems are not available, contour bunding with earth can be done. This means a construction of low earth dams (20 cm in height) along the contours between every or every other tea row. Behind these dams the rain water can gradually infiltrate into the soil. This system reduces the speed of the surface run-off, keeps the top-soil in place and can function as a barrier against soil erosion in new clearings as well as in mature tea fields.

6.6 Infilling

Infilling tea plants in patchy tea fields should be done at the beginning of the rainy season, which is the optimum planting time. To avoid unnecessary walking and searching, all operations of infilling, such as detecting the failure, digging a new planting hole, and infilling the new tea plant, should be done by the same labourer.

7 Summary

Out of 66 tea plantations in the Darjeeling District, only five tea plantations have started to change from conventional tea cultivation to ecological tea cultivation. There are two plantations under conversion at present. Ecofarming also means a loss of 30-40% of production in the first 3 years, but comes down to 20% after five years. But on the other hand, the prices for eco-teas are much higher (40-50%), and the demand for eco-teas in the European market is sharply increasing. For the planters, it is a very challenging task to start with ecofarming. Besides the higher input costs, strong and reliable market linkages must be established in order to find buyers for the more expensive eco-teas.

Under the unique growing conditions in the Darjeeling Hill Country, tea is the only economic crop (Domroes 1993). But tea cultivation in this region is in a crisis due to the decrease of productivity of the over-aged seedling tea bushes. Large replanting activities have to be carried out in future, although the majority of the Darjeeling tea planters repress and underate this fact. For the Darjeeling area, ecofarming will be an important solution for a sustainable development of the agricultural sector. Major attention should be given to soil conservation and afforestation. A qualified scientific organization should supervise, overlook, and control the efforts of ecofarming in the Darjeeling tea growing areas in order to guarantee a vital future for the world famous Darjeeling tea.

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