Ecological and Economical Aspects of Tea Cultivation in Northern Thailand - Tea as an 'Opium Suppression Crop'?

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1. Introduction

Tea has been the most important tree crop for smallholders in the highlands of Northern Thailand for the last 100 years. Hilltribes established tea gardens by simply thinning out the forest trees around existing wild tea trees. These early growers produced the fermented tea called *miang*. Later, in the early 1900s and again in the early 1950s, Chinese migrated to Northern Thailand from China via Burma; these Yunnanese immigrants (Chinese Haw) introduced the production of green tea in Tambon Wawi (Chiang Rai Province). The green tea machinery was transported into the hills on elephants by the remnants of the Koumintang Army (KMT 93 Force), which moved from Yunnan to Northern Thailand after the communist revolution in China.

During the past two decades, the greater part of the traditional *miang* gardens have switched to green tea production; the Chinese now control most of the tea gardens in Northern Thailand. This change of production pattern is supposed to be one of the main reasons for the severe decline of tea production in Northern Thailand, amounting to over 50%.

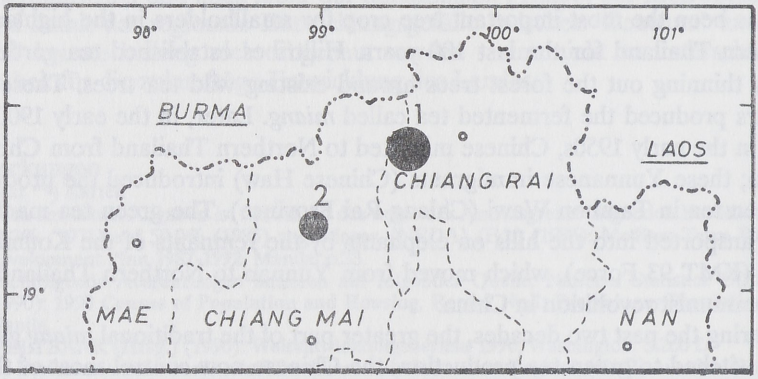
Northern Thailand is geographically part of the 'Golden Triangle', the frontier area between Thailand, Burma and Laos, well-known for its opium and heroin production. The continuous decline of tea growers' incomes has led them to turn to opium production (Kinit 1990). This should be an alarm signal for all international organizations working in drug suppression matters. So far, only the Thai-German Highland Development Programme (TG-HDP) in conjunction with the Public Welfare Office, has directed its attention to the tea growing areas in Tambon Wawi by setting up a 'Three Year Tea Improvement Plan' (Hoare 1987) and by establishing demonstration plots of high density tea planting. Additionally to Hoare's very valuable report, a detailed investigation of the agro-ecological growing conditions for tea is necessary and its findings should be taken into consideration when giving agro-economical recommendations in order to ensure increased productivity of tea in Northern Thailand.

In the author's opinion, tea might be one of the 'key crops' capable of functioning as an 'opium suppression crop' in the presently very neglected tea industry of Northern Thailand. The article seeks to provide an introduction to the tea industry in specified areas of Northern Thailand, to describe and analyze the main environmental factors affecting the productivity of tea, to present and to discuss - in addition to Hoare's work - some important findings and recommendations concerning agro-ecological and agro-economical measures intended to increase the yield potential of tea in Northern Thailand.

2. Areas Studied and Types of Tea Produced there

During his research visit to Northern Thailand the author concentrated on two tea growing areas (Map 1):

Map 1: Location of the studied tea growing areas Tambon Wawi (1) and Chiang Dao (2)



- Tambon Wawi located in Mae Suai District of Chiang Rai Province: about 60% of green tea in Thailand originates from this area which is located at an elevation of 800 m a.s.l. and consists of 33 villages with 95 green tea factories. Apart from the green tea production which has been established over the past 25 years, *miang* or 'pickled' tea is still manufactured there. Tree density on the approximately 6,000 rai (1,000 ha) tea garden area reaches only 250 tea trees/ hectare (Assam, India: 10,000 tea bushes/ha); This very extensive way of cultivating tea by harvesting wild tea trees, most of which are over 40 years old, instead of properly pruned tea bushes results in the very low productivity level of only 167 kg processed tea per ha (Assam, India: 2,800 kg processed tea/ha), considered the lowest yield in the world. The average size of the tea gardens per owner (total 132) is 7 ha but varies from 0.6. ha and 80 ha.

-Chiang Dao District located in the Chiang Mai Province: apart from approximately 80 *miang* orchards (average size 0.5-1 ha), a commercial high density tea plantation with black tea production is situated in this area. Cha Siam Tea Plantation (formerly Raming T.P.) was founded in 1960 by planting 80 ha with tea. The land concession covers 312 ha. Cha Siam produces 85% of the black tea in Thailand. There is 60% import duty on tea, which gives Cha Siam (owned by Royco Foods; Lipton) a monopol position for black tea. About 55% of the green leaf is bought from the surrounding smallholders, former *miang* orchards, for 6 Baht/kg (1 US$ = 24 Baht) if the green leaf has about 80% buds and the first two leaves.

The harvested leaves of the mainly wild tea trees are used to produce four types of tea, such as pickled tea or *miang*, semi-fermented Chinese tea, green tea,

and black tea recently introduced in Cha Siam Tea Plantation, the differences between them arising solely from differences in treatment.

Miang or pickled tea is consumed in Northern Thailand as a part of social custom. Especially when visitors come or when the family gathers in the evening, *miang* is passed around. Each person takes a small bundle of leaves, rolls them up into a wad, like chewing tobacco with a lump of salt in the center. Both men and women use it daily. *Miang* is made of tea leaves which are picked four or five times a year during the 7-month rainy season. About two-thirds of the semi-mature leaves are harvested. The second pick is the largest, yielding approximately one-third of the total annual harvest. Due to the height of the tea trees (5 m), leaf picking is a very time-consuming and uneconomic task. The picked leaves are tied into small fist-sized bundles (*kam*). The output of an average picker is 50 *kam*/day for which the *pawliang* pays 30 Baht. Most of the picker families who do not own or rent orchard land but entirely depend on daily labour.

Processing of the leaf is carried out in a *hai*, i.e. a fire pit with a large iron boiler placed above it on two iron poles. The leaf-bundles are packed tightly into a wooden barrel with a bamboo mesh at the bottom which is then placed over the iron boiler. The top of the barrel is covered with banana leaf to keep the steam from escaping. After 90 minutes the bundles are removed and carefully packed into large bamboo baskets (*tang*, accommodating 330 *kam*) lined with banana leaf. For a minimum of 6 weeks the *tang* remains inside for fermentation. While some is kept for household consuption, the rest is taken by pack animals to the markets of lowland towns. The average *miang*-production per family unit is 20,000 *kam*/annum.

Green tea is a non-fermented product, where enzymes in the tea leaf are killed by heating the leaf to about 80 to 110° C in flat pans and drum panners. The main variables in the panning process where the leaves are turned by hand, are the temperature of the pan, the amount of leaf and the duration of panning (Hoare 1987). In the drum panners approximately 20 kg of tea leaf are roasted for 7 to 10 minutes. Thereafter the rolling process takes place; this is necessary to twist the leaf, to break it up, and to release the leaf juice. In the final drying process, the moisture content of the tea is reduced to 3-5 %. This is done by oven-drying (15-30 minutes) or by sunlight-drying on traps outside the factory (5-10 hours). The poor standard of the equipment leads to a poor quality of green tea which accordingly fetches a very low price. Semi-fermented green tea is made when the enzyme is only partly killed in the panning process resulting in uncontrolled and uneven fermentation. Owing to the poor quality of the tea leaf brought to the factory (coarse leaf) and of the processing equipment, most of the produced tea is semi-fermented green tea of very low quality. This tea of a green to brown colour, is made for tea bags and sold for only 16-20 Baht/kg.

Black tea is produced by first withering the leaf for a minimum of 6 hours (loss of moisture). The purpose of the rolling process is to primarily break up the leaf cells and to mix up the chemical components of the leaf with the enzymes. The process of fermentation comprises a series of complex chemical reactions, such as the oxidation of polyphenols. Flavour compounds are known to be formed early in fermentation but are partially lost again during the process so fermentation is kept as brief as possible. The process of firing removes most of

the leaf moisture and stops fermentation by destroying the enzymes, resulting in a black-coloured tea.

3. Development of the Tea Gardens and the Present Situation

Over the past two centuries, tea gardens for *miang* production were established in Northern Thailand using the indigenous Assam variety (Camelia assamica). The traditional way of establishing a *miang* plantation in the past, was simply to clear the native forest around already existing wild tea trees. It is only in recent years, that some *miang* farmers have increased the tree density by clearing further forest areas and planting tea seedlings taken either from existing wild trees or from established seed nursaries in the cleared patches. There is a total absence of subsistence cropping in this area. The tremendous variations in tea tree density per field as also in yield per tree make an estimation of yield per unit very difficult. By law, forest land is strictly forest reserve and may not legally be used or occupied. Due to the high population growth in the lowlands, the government had to accept the factual occupation of reserve forest land and granted usehold titles to the farmers; this in turn has led to a further severe forest destruction. At present most of the native forest cover has disappeared, cut either for the valuable timber (especially teak: Tectonia grandis) or for fuel wood in the fire pits. Since 1960, the peasants have had to pay an annual tax on former forest reserve lands, but the rate is very nominal, amounting to only 10 baht/rai/annum (6 rai = 1 ha).

The central figure in the *miang* economy is the *pawliang*, literally the "father who feeds us". He is either a landlord, who owns *miang* orchards and rents out his trees for picking to the village labourers, or a man who has aquired a government title of land on which the peasants live and for which they pay the traditional rent portion. For a rich local man it is very easy to buy a usehold title for 60 baht/ha/annum. At present most of the tea gardens in Tambon Wawi are under the custom ownership of the Yuannanese (Chinese Haw).

The *pawliang* also functions as a money-lender and wholesaler, buying the leaf from the growers. An interviewed peasant in Chiang Dao stated that if there was no obligation to sell the leaf crop to the *pawliang* a direct sale of the leaf crop in the market would double the income of the growers. At present pickers earn 2-3 Baht/kg tea leaf from the *pawliang*. A good picker can harvest 40 kg/day (=80-100 Baht/day), the average wage per day being 50-80 Baht.

Almost all northeners over the age of 25 consume *miang*, but only just 50 % of the younger group. Out of the considerable number of immigrants from the lowlands, only 20 % have adopted the habit. The declining trend in *miang* consumption and the limited efforts to overhaul the *miang* economy have led *miang* growers to sell their surplus leaf to the green as well as the black tea factories in their vicinity. During the last two decades, the amount of harvested fresh leaf has declined by over 50 % (Hoare 1987), which created a large number of problems for the proprietors of tea gardens, the owners of tea factories and of course, for the labourers who are most seriously affected by decreasing incomes or even unemployment. As the remote tea growing areas are characterized by a non-

diversified economy, as well as by a very limited infrastructure there are very few other sources of income available to farmers in times of declining tea productivity - except the expansion of the already existing poppy cultivation for opium and heroin production. Today Thailand is one of the principal opium growing countries in Southeast Asia; it is involved as a producer, as a processer and as a trans--shipment area.

Poppy (Papaver somniferum) for the production of opium is mainly grown in remote areas, on hill tops and on hidden slopes above 800 m. In 1989, opium production is believed to have reached about 50 tonnes/annum, enough to produce 5 tonnes of pure heroin. Manufacturing is partly done in Northern Thailand but mostly in factories in Burma under the armed purview of Khun Sa, known as the 'drug overlord' in the Golden Triangle (Lintner 1990).

The Thai-German Highland Development Programme (TG-HDP) funded by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) and by the Office of the Narcotics Control Board (ONCB), both based in Chiang Mai, selected several pilot project areas in Northern Thailand in order to implement sustainable and integrated farming systems for the target groups of impoverished hillfarmers. The Regional Rural Development Project includes measures, programmes and activities mainly in the fields of agronomy, animal husbandry, forestry, water and soil conservation and management, public health, education and infrastructures. The aim of the project is to secure a sufficient income for the hill tribes so that they do not have to resort to poppy cultivation and could also give up the pattern of shifting cultivation previously practiced and considered highly land-intensive (Dirksen, 1990).

4. Geographic Features of the Tea Growing Areas under Study

The profitability of tea production depends on the factors involved in the surroundings of a tea plant that affect it directly or indirectly. The major relevant factors are:

4.1 Topography and Soil

The northern region of Thailand lying between 15° and 21° N and 97° and 102°E covers an area of about 170,000 sq km which amounts to approximately one third of the total land area of the kingdom. The entire region consists of a series of parallel and longitudinal folded mountain ranges in continuation of the Central Asian system. Between the typical northern mountain ridges there are relatively flat intermontane plains, basins or valleys opening to the south.

The topography of the northern region is commonly divided into three major land forms:

- the lowlands: below 200 m a.s.l., fertile alluvial areas characterized by flat to a gently undulating landscape;
- the uplands: elevations ranging above 200 m and below 500 m, terraces lying between the tributaries of main rivers and along the foothills of the ranges, characterized by an undulated to hilly topography; and

- the highlands: from 500 m to 2,500 m, flat plateaux or mountains with steep slopes.

The studied tea growing areas of Chiang Dao and Tambon Wawi are located in the highlands of the Chiang Mai and Chiang Rai provinces respectively.

The topography of the Chiang Mai province is determined by the mountains of the north to south oriented Doi Inthanon Range (Doi Inthanon 2,590 m) and the valley of Chiang Mai (314 m) with the river Mae Nam Ping. The studied tea growing area in the Chiang Dao District (70 km to the north of Chiang Mai) is to be found on the mainly steep (30-60 % inclination) to very steep (more than 60 %) westerly exposed flanks of the Doi Inthanon Range. Tea is grown in the highlands at altitudes ranging from 700 m to 1,200 m a.s.l. The underground consists of quartzitic and silicious sandstone. The soils are mainly shallow and appear very gravelly, resulting in low fertility.

The topography of the Chiang Rai province is comprised of several mountainous ranges. The studied tea growing area in Tambon Wawi is located in the eastern part of the province and can be characterized as a transitional region, topographically influenced by the mountains of the Daen Lao chain and the Khun Tan chain with a number of ranges split off, and form together with the north-to-south as well as east-to-west running rivers, a sequence of valleys, intermontane basins and ridges. Tea is grown in these highlands at an altitude of 600 to 900 m a.s.l. The greater part of the slopes are steep to very steep and generally exceed 25 % inclination, characterized by mainly western and eastern expositions. The soils originated from granitic and metamorphic rocks, they are shallow and coarse marked by low fertility.

4.2 Climate

Before presenting the climatic analysis of the studied area, it is necessary to give a brief introduction of the agro-climatic requirements of the tea crop.

With regard to climate the tea bush is generally very adaptable. The minimum annual precipitation considered necessary for a successful cultivation of tea is 1,200 mm, while the optimum amount ranges between 2,500 and 3,000 mm (Fuchs 1989). There does not appear to be an upper limit to precipitation. The distribution of precipitation throughout the year is of far greater importance than the annual total amount. An even annual course of precipitation ensures optimal leaf production and high tea yields. Drought periods with precipitation of less than 50 mm per month over a longer period result in a reduction of leaf production followed by a loss of crop.

The range of air temperatures over which growth takes place is between 13° C and 30° C. An annual average temperature between 18-20° C is generally considered ideal for the tea bush. In full sunshine, when the ambient air temperature is 30-32° C, leaf temperature can rise to 40-45° C. Horizontally posed leaves of the Assam type generally have a higher leaf temperature compared to the semi-erect and smaller leaves of the China type. Photosynthesis steadily increases up to 35° C, but sharply declines at 39-42° C, whereas respiration increases until the leaf is irreversibly damaged above 48° C. Soil temperature can drastically influence the growth of tea. The optimum temperature appears to be around 24-30° C, whereas growth is poor at 10-12° C.

The duration of daily sunshine is another factor of agro-climatic importance. A mean daily duration of less than 5 hours over a 4-5 day period increases the occurrence of the fungus disease called Blister Blight (Exobasidium vexans), which causes a decline in productivity. But more than 5 hours of sunshine per day ensures protection against the destructive fungus attack. The tea bushes are able to tolerate light winds without any adverse reaction. But in case of strong and particularly dry winds, the bush can be defoliated. The higher transpiration rate and drying-out of the soil result in late leaf production, which leads to a decline in yield.

In general the climate of Thailand is monsoon tropical with alternating wind regimes, such as the southwest (wet season) and the northeast monsoon (dry season). The nature of the rains is both orographic and cyclonic (Domrös 1980).

As a function of the relief, the climate of Northern Thailand is characterized by a considerable number of meso-climatic sub-regions as a result of the high and steep mountain chains running north-to-south. They are climatic barriers and act as rain producers on one side and as dry weather promotors on the other. The climatic differences between the intermontane valleys and the high mountains are very large.

Climatological data of Cha Siam Tea Plantation concerning daily temperature and precipitation (1987-1990) and monthly yield figures were provided by Chris Marley, Manager of Cha Siam. Unfortunately, no data are available for Tambon Wawi area. During the research visits in this area, many tea growers were questioned about the annual variation of precipitation. The annual precipitation pattern is similar to the one in Cha Siam. For the trend analysis (regression lines) of the inter-annual precipitation variation, long-term data of Chiang Mai was taken into consideration (Northern Weather Forecasting Centre, Chiang Mai).

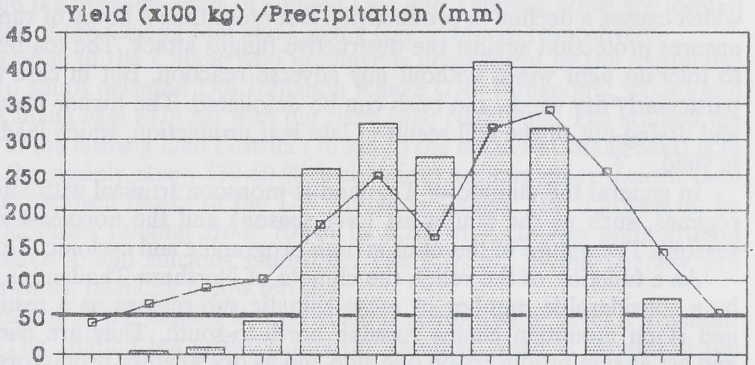
4.2.1 Precipitation

The mean precipitation for the studied tea growing areas amounts to 1,865 mm (Sri Lanka: 3,037 mm/187 rainy days; Fuchs 1989) received in 127 rainy days/annum which is still sufficient for successful tea cultivation. As indicated above, the annual distribution of precipitation is of great importance (Fig. 1).

The tea areas receive their first considerable annual precipitation during the passage of the Inter Tropical Convergence Zone (ITCZ) in April (44 mm) and especially in May (261 mm) when the zone moves north. These are convectional rains mainly occuring in early afternoon in the form of heavy rain storms and thunder showers.

In June and July the movement of the ITCZ comes to a standstill, resulting in a fully developed southwest monsoon culminating in orographically-conditioned precipitation (western exposition of the tea growing areas) reaching its first annual maximum in July (323 mm). A slight decline already occurs in July (276 mm). This could be explained on the one hand as due to decreasing precipitation effectiveness of the air masses throughout the southwest monsoon regime and on the other hand as due to the location of the studied area in 18° N over which the ITCZ moves twice in 3 months which results in a short as well as weak development of the southwest monsoon.

Figure 1 Mean monthly yield and precipitation CHA SIAM Tea Plantation (1987-1990)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation	0	4	9	44	261	323	276	408	316	149	75	0
Yield	40	67	88	100	180	250	162	315	340	255	140	55

Source of data: Pers. Notes, Chris Marley, Plant. Manager

The bimodal precipitation pattern is obvious due to the second annual maximum in August (408 mm). This is the period when the ITCZ shifts to the south causing precipitation for the western exposed tea slopes. The mean monthly value is still high in September (316 mm) but sharply declines from October (149 mm) onwards both as regarding monthly precipitation values and monthly number of wet days. This indicates the onset of the northeast monsoon which is characterized by cool and dry air from China flowing across Northern Thailand. The westerly exposed tea slopes are located in the rain-shadow of the north-to-south running ranges and the katabatic winds are already rained-out. During the six months from November to April the tea lands receive only 132 mm, i.e. a mere 7 % of the total mean annual amount, so that with the mean precipitation falling below the critical value of 50 mm, the tea bushes suffer due to moisture stress.

The annual curve of relative air humidity nearly coincides with the annual precipitation distribution, characterized by a 4-month maximum period of 85-87 % (June to September) and by a minimum period of 48 and 50 % in February and March.

4.2.2 Temperature

The mean annual temperature of 21° C (Chiang Mai: 25° C) is considered ideal for tea cultivation. The highest temperatures (mean monthly maximum) are measured in March and April amounting to 35° and 36° C. A cloudless sky

during the day causes a high insolation intensity. This period is definitely the most critical period of the year as high temperatures in the absence of sufficient precipitation cause severe water stress for the perennial crops.

The mean annual minimum temperatures are reached during the northeast monsoonal period ranging from 16° C in November and February to 14° C in December and January. They result from the intensive nocturnal radiative energy loss under cloudless conditions. This energy loss is increased in case of dry soil and poor vegetation cover because of the small heat storage capacity. Frost does not occur in the studied tea growing areas nor is the critical mean air temperature of 13° C reached.

4.2.3 Climate and Yield

Fig.1 shows the close relationship between precipitation as the major control parameter and tea yield (Fuchs 1989). Towards the end of the second intermonsoonal phase in September productivity concurrently declines with monthly precipitation and temperature values till it reaches its annual minimum in January (40,00 kg). From February onwards relative air humidity, temperature and precipitation show an upward trend which coincides with the increase in productivity of tea. The most favourable growing conditions for tea are reached in May during the passage of the ITCZ when high temperatures, sufficient precipitations occuring in early afternoon and direct sunlight during the first half of the day ensure a satisfactory growth rate of the tea bushes. A large number of pluckable shoots are produced towards the end of May which leads to a further productivity growth in June, although the weather conditions are not as favourable. With the onset of the southwest monsoon, the sky is cloudy during the greater part of the day. Fewer daily sunshine hours lower the growth rate of the tea bushes as well as favour Blister Blight attacks which weaken the bushes. The resultant markable productivity decline starting already in June reaches a maximum in July. Thereafter during the second annual passage of the ITCZ, weather conditions with sufficient sunshine and precipitation improve again. The large number of shoots produced towards the end of August cause a further productivity increase, reaching its annual peak in September although precipitation reduces already.

The main yield constraint in the tea growing areas is thus precipitation, in the sense that the long annual dry spell and the unfavourable agro-climatic impacts during the southwest monsoon distinctly reduce yield. The lower temperatures during the northeast monsoon definitely lower the yield potential in an additional manner, but their influence is not primarily yield-determining.

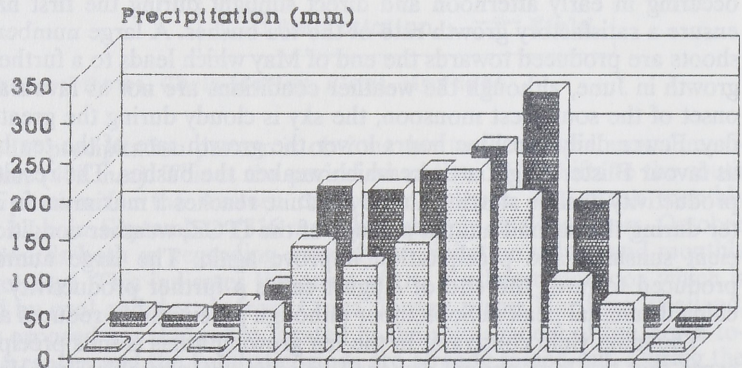
4.2.4 Climatic Change

The author's analysis of inter-annual precipitation variation for Chiang Mai using long-term data (1951-1987) shows besides the tremendous variation from year to year, a considerable decline of the mean annual precipitation as well as of the number of annual rainy days for the 36-year period. In the early 1950s annual precipitation amounted to 1,400 mm but thereafter, continuously lessened reaching values of 1,050 mm in the mid 1980s while the annual number of rainy days fell from 135 to 112.

A possible reason for the declining precipitation values is the deforestration which has widely taken place in Northern Thailand. During the last 50 years about 60 % of the primary tropical rain forests were destroyed by shifting cultivation, extraction of valuable timber and growing need for firewood. The intermontane basins have become a cultural landscape with hardly any forest cover left following human settlement. In 'summer', when the paddies are submerged, the basins are a cultural swampland and in the dry 'winter' they turn into a 'cultural steppe'. Even the mountainous areas have been converted into farmland resulting in a tropical savannah due to the short rotation cycle. A considerable proportion of precipitation is derived from transpiration inside the rain forests. Hence it is very likely that, when rain forest areas are cleared, the rate of precipitation will decrease both locally and outside the cleared areas. This will affect other ecosystems and farmland in terms of declining productivity.

For agricultural planning it is important to know the part of the year in which severe decline has taken place. For this purpose the inter-annual precipitation variation for Chiang Mai was seperately investigated for each month by a trend analysis. In Fig. 2 the monthly trend averages of the early 1950s and the mid 1980s (starting and ending point of the regression line) are compared.

Figure 2 Trend analysis of the monthly precipitation means (1951-1987) for CHIANG MAI



	J	F	M	A	M	J	J	A	S	O	N	D
TA early 1950s	15	12	25	50	180	175	200	230	300	160	25	10
TA mid 1980s	5	0	5	50	135	110	140	235	195	90	60	12

TA = Trend Averages

Source of Data: Northern Weather Forecasting Centre, Chiang Mai

The change of weather pattern indicated by the decline of annual precipitation was not even for each month of the year. The main decline took place during the second inter-monsoonal period viz. September/October and in the second half of the annual dry spell viz. January to March. These two periods are most

important for the yield and bud production respectively. Especially the decreased water supply towards the end of the second inter-monsoon period reduces the moisture stored in the soil required by the plants during the long annual dry spell, which again is characterized by a severe water deficit. The only advantageous change is to be found in the month of November, marked by an increasing water supply. The precipitation reduction during the southwest monsoonal period viz. June and July, does not have considerable yield declining impact for tea, because less clouds might reduce the disadvantageous fungus attack rate.

The bimodal pattern remains the same but in the long term studied here the annual precipitation maximum has shifted from September to August. Due to the absence of rain forests, transpiration is low which means less moisture availability and uptake during the convectional air movements (passage of the ITCZ) resulting in lower precipitation values.

For all the months except for November, December and April the mean monthly precipitation values at present are lower than those in the early 1950s. A reduction in moisture supply will in many cases reduce plant growth and so reduce respiration associated with growth. If water stress is severe it will cause cellular damage. In drier tropical ecosystems, moisture (in the air and soil) often functions as the primary controller of canopy development and leaf senescence and precipitation functions as a primary determinant of the length of the growing seasons (Melillo 1990).

In the intensively cultivated valleys of Chiang Mai annual precipitation values are very close to 1,000 mm where tea growing would not be possible any more. At Cha Siam precipitation at present amounts to 1,850 mm annually which is sufficient for tea cultivation. Due to the lack of long-term data for Cha Siam the precipitation trend there cannot be estimated, but the author assumes that there, too, a change in the precipitation pattern has already occurred.

5. Conclusion and Recommendations

The aim must be to improve tea cultivation in Northern Thailand by intensifying it in selected units in a tea garden which gives space for crop diversification in the remaining units, thus reversing the declining trend in the tea industry of Northern Thailand and ensuring at the same time sufficient income for the peasants in the highlands. Tea as the main cash crop in an integrated farming system may also function as an "opium suppression crop".

In order to reach this aim a large number of innovative efforts have to be made. The observed change of weather pattern, severe degradation of land and the traditional way of uneconomical tea cultivation and processing imply a challenging task for the target groups (hill-tribes), as well as for the agencies involved in setting up and implementing sustainable rural development programms.

In the author's opinion, an intensification of tea cultivation on the entire land in Tambon Wawi and the neighbouring gardens of Cha Siam would not be a solution as it would lead to a labour shortage during the 'rush cropping seasons' in May/June and August/September. Even if the labourors could be trained to harvest all the crop, severe under-employment would occur during the long annual dry spell where tea production is nearly at a standstill. An overall in-

creased leaf harvesting will also be uneconomic due to the limited manufacturing facilities. Taking into account the already mentioned decreasing demand for **miang** tea, growers should convert their **miang** tea gardens to supply their harvested leaf to the neighbouring green tea factories, as well as to Cha Siam where black tea is produced.

Tea cultivation as a cash crop could be intensified in selected units of a traditional **miang** or green tea orchard, characterized by a high percentage of well-yielding healthy tea trees on slopes of less than 40 % inclination on moderately degraded soils. The remaining units with still existing tea trees should be:

- planted with subsistence crops if the area is located in valley bottom or on less steep slopes,
- reforested, particularly on slopes with a gradiant exceeding 40 % which are unsuited for growing any other crops,
- turned into pasture land by fencing them off from other units.

Such a farming system in the traditional *miang* tea gardens consisting of cash crop (C), subsistence crop (S), forest (F), and pasture land (P) - the CSFP-farming system - , might be a long-term solution for the present crisis in the tea growing areas of Tambon Wawi and Chiang Dao. The land ratio for each component of 'the CSFP-farming system' is very flexible, depending on the present situation and could be 3:1:5:1 or 3:2:4:1.

The level of investment for *miang* cultivation and processing is very low. Many factories in Tambon Wawi have outdated machinery and insufficient factory capacity. Modernization and construction of new factories are urgently needed. This presupposes the setting up of economically viable rural financial institutions, specialized farm credit institutions with a low-interest policy, self-help groups formed by independent farmers to collectively achieve designated goals. But the key factor must be the initiative of the inhabitants of rural areas, such as smallholders, who are willing to reach economic independence and flexibility.

Improvement of credit and marketing organizations would solve the problem of indebtedness of the *miang* or green tea producers without losing the expertize of the *pawliang* wholesalers, who form an essential link between the producer and consumer.

5.1 Recommendations for the Cash Crop Tea (T)

The primarily important agro-techniques and innovative practices for converting selected traditional *miang* tea units into high density tea units are pruning, planting and manuring.

Pruning: Pruning is essentially the artifical removal of the leaf-bearing branches of the plant; it may involve most of those branches. The operation is aimed at keeping the size and vegetative vigour of the plant for maximum vegetative growth and cropping. The main objectives of pruning are maintenance of a convenient height for easy harvesting, stimulation of vegetative shoot growth instead of flower and fruit growth, maintenance of a healthy frame, effective utilization of the hectarage and stabilization of crop.

The traditional tea growing countries (India, Sri Lanka) established several types of pruning generally referring to the height of the remaining branches above ground level. For the studied tea growing areas in Northern Thailand the

author recommends a 'rim lung prune' at the height between 40-55 cm. This means a partial removal of the existing branches leaving one thick branch with all leaves. Such a 'lung' advances bud break and generally reduces die-back and casualities. 'Lungs' also provide a certain amount of shade which is important as tissues are liable to scorch after short periods of exposure to direct sun due to the rise in bark temperatures amounting to 10-15° C above the ambient air temperatures. Some of the prunings should also be placed over the tea plant providing some shade during the first few days after pruning when the bark is most vulnerable to sun scorch. Thereafter the thin prunings should be kept around the pruned tea tree or should be incorporated in the soil thereby enriching it with nitrogen, phosphate and potash. The thick prunings may be used as firewood in the households.

The ideal time for pruning is April, when sufficient soil moisture is available and ensures that recovery and vigour of the plant will not be impaired. It is true that pruning means also a temporary loss of crop but this loss can be ignored when one considers the long-term health and leaf-production of the plant. Tea smallholders and owners of larger tea gardens should start to prune at least 10 % of their tea trees per annum. Tea trees will take much longer to recover from pruning (at least 6-7 months) than well-maintained tea bushes (3 months). The pruned tea tree first produces shoots on the pruned stem and the remaining thick branches and later laterals upon the primary shoots. The 'lung' should be removed when most of the new shoots habe developed 2-3 fully expanded leaves (approximately 12-16 weeks after pruning). The foliage of the developing tea bush has to be tipped at a height of 15-20 cm from the prune cut.

Thereafter commercial tea plucking can start. The climatic conditions would allow plucking every 12-15 days instead of only 4-5 times per year. Due to the large number of plucking points, two leaves and a bud can be plucked, out of which quality tea could be produced and sold at a high price. The bushes should be tipped plucked at a slope parallel to the lie of the land; the side branches if left untouched will increase their growth rate resulting in a 'plucking table' where no branch and leaf is shading the other. After 6-7 years the bushes should be pruned again.

The interviewed smallholders in Tambon Wawi and Chiang Dao have never pruned their tea trees, and it will be very difficult for them to adopt this agro-technique. They believe that their tea trees of 4-5 m in height will never recover from pruning and die. When Chis Marley, Manager of Cha Siam, took over the plantation, he pruned (clean prune: no lungs left) his tea trees at the height of 40 cm and 90 % of them have survived (Marley 1990). Therefore proper training of the inexperienced tea smallholders is necessary for implementing the pruning programmes.

Planting: To intensify tea cultivation in the selected units it is necessary to fill the large gaps between the existing tea trees by planting new tea bushes. In the traditional tea growing countries clonal bushes which are drought-resistant and productive for 40 years are mainly used for replanting purposes. As similar growing conditions prevail in the Assam valley (NE India), the Tocklai Tea Experimental Station in Jorhat, Assam, would be an ideal counterpart for replantation activities in Northern Thailand.

Suitable planting material could also be obtained from seeds of high-yielding local 'mother trees'; or such trees could be pruned and 100 cuttings from each of them could be laid out in the nursery (vegetatively propagated). After 12-15 months the young tea plants should be transplanted into the fields on contour lines between the existing tea trees leaving enough space and small footpaths for plucking the old tea plants. Unproductive and weak tea trees could be ring-barked and uprooted after 3 months. In order to establish high density planting the spacing between the plants should be 75 cm, and between the rows 110 cm, which would lead to a ratio of 12,000 plants/ha. The ideal time for transplanting would be from the end of April until mid June. There are three basic methods by which a tea plant can be trained to form a low bush, such as decentering, lung pruning, and bending (Borbora 1988): In decentering the main stem of the young plant is removed at a height of about 20 cm from the ground at three weeks after transplanting; in lung pruning the stem is half broken at about 20 cm leaving the tissues on one side intact (for water and nutrient movement); the broken portion is bent towards the ground and removed when the new branches below have produced mature leaves; in bending down the stem the growth of laterals is stimulated, which are in turn pegged to obtain greater and early spread of the bush. If properly done, this process will take approximately 3-4 years until the tea bush is in a productive stage.

Care and maintenance for the young plants must be ensured by well-trained farmers; a district training centre is essential. Beside the tremendous productivity increase, a more densely planted area would also secure protection of the soil and watershed resources.

Manuring: Tea, like any other crop requires 16 essential elements. Carbon, hydrogen and oxygen, freely available in the atmosphere, make up the bulk of the plant tissue. Out of the remaining 13 elements, N (nitrogen), P (phosphorus) and K (potash) are known as major essential elements.

Hoare (1987) reported that the owners of *miang* tea gardens in Tambon Wawi applied 3 kg NPK fertilizer per old *miang* tea trees, costing 20 Baht/tree. After a small yield increase in the first year, the yield shot up in the following two years to more than double the leaf quantity. Thereafter the yield returned to the previous level. The method of fertilizer application in steep *miang* orchards was to dig a single hole about 0.3 m from the trunk on the uphill side and to deposit the fertilizer there. Some farmers clean-weeded a one metre circle around the tree in order to avoid nutrient uptake by the weeds. From the ecological side this has certain disadvantages as due to the exposed soil surface, the evaporation rate is increased which might lead to water stress conditions during the annual dry spell; also the soil temperature is then higher (insolation), which decreases the activity of the soil organisms. Free-grazing cattle might harden the soil surface which decreases the water penetration and infiltration rate during the rainy period. An exposed soil is also prone to wash-off by excess surface water during the wet season.

A much better method would be to apply a thick layer of mulch material (10-15 cm). The advantages of this systems are protection against any weed growth, addition of organic matter and nutrients, conservation of the soil water, improvement of the soil tilth, reduction of surface temperature and surface run-off. The required mulch material can be rice chaff or straw, prunings, lop-pings and cuttings from native grass.

For transplanted young tea plants a mixture of sulphate of ammonia (NPK ratio: 2:1:2) at a quantity of 40 kg/ha/annum in four splits is recommended and should be increased up to 100 kg in the fifth year (Sinha 1988). Each existing tea tree which is converted into a bush by proper pruning should receive twice a year 50 grammes NPK (end of April and July) by forking the fertilizer on the uphill side in a half circle of 0.5 m radius around the trunk in case of steep slopes, in flat land in a full circle.

Due to frequent fertilizer application it would be possible to pluck the bushes throughout the year and thus provide a certain amount of employment during the annual dry season, too. Irrigation leading to a further productivity increase would be ideal, but the financial input involved would definitely exceed profits. Only in the large tea gardens irrigation is profitable, such as in Cha Siam.

5.2 Recommendations for subsistence crops (S)

Selected units in a *miang* orchard should be planted with subsistence crops viz. upland rice, corn, legumes, red kidney beans, ginger or wheat. The TG-HDP has developed and successfully implemented a 'soil and water conservation programme' (SWC-programme), the main elements of which are contour line planting, contour grass strips (buffer strips), rotation, zero-burning, fertilizer application, close planting, and cover crops (Dirksen 1990). Such programmes are highly recommended for the selected subsistence crop units in the *miang* gardens.

5.3 Recommendations for Re-forestation (F)

Giant bamboo (large variety) and bamboosa (small variety), the fastest growing plants in the world, could be planted along large ravines and water courses. Cut bamboo can also be used for making plucking baskets, in a *miang hai* and for building houses. Due to the increasing local demand for and price of firewood, selected small units (0.1 to 0.2 ha) should be planted with fuel wood species viz. 'Casurina equisetifolia', 'Cassia siamea', 'Acacia arabica', and 'Acacia auriculiformis' or with fast growing eucalyptus trees, such as 'Eucalyptus torolian' and 'Eucalyptus grandis' (4m x 6m).

Besides planting commercial wood, re-forestration should be directed at restoring the natural species. The 'deciduous dipterocarp forest' is the typical forest in North Thailand mainly consisting of 'Shorea obtusa', 'Dipterocarpus tuberculatus, obtusifolius', and 'intricatus' (Donner 1978). The typical forest in Tambon Wawi is the 'mixed deciduous forest' characterized by the above mentioned species but additionally involving many very valuable and internationally traded timbers such as 'Tectonia grandis', 'Pterocarpus macrocarpus', 'Xylia kerrii' and 'Lagerstroemia calyculata'. On the western slopes of the Doi Inthanon Range (Cha Siam area) conifers form entire forests consisting of 'Pinus merkusii' and 'Pinuskassia'. Associated with deciduous dipterocarp forests, they form a xerophyle vegetation cover.

5.4 Recommendations for Pasture (P)

Keeping cattle in fenced areas would also solve the present problem of free-grazing cattle likely to damage young tea plants as well as cultivated subsistence

crops. Cattle dung could be used as organic manure for the cultivated crops. Commonly kept animals are cows, buffalows, ponies and mules as pack animals. Almost all hill-tribes raise and eat pigs and sell them when a surplus is available. There is scope for improvement in this sector leading to an additional source of income for highland farmers.

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