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Patterns of forest use and its influence on degraded dry forests:

A case study in Tamil Nadu, South India

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„IN THE FIRST PLACE WE HAVE TO FIND SOLUTIONS FOR MAN;
NOT FOR THE FOREST"

Anonymus

For my parents

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As I started this study I was not aware of the dimensions of the work I had chosen to undertake. To make it a success, was not just a matter of raising funds and going to India. Struggle in the German and Indian administrative jungle, slow progress of simple things, stressful fieldwork, broken computers, dealing with new software as well as deep valleys of frustration and loneliness were my companions. Without the assistance of so many good people, I would not have been able to conduct this study.

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God bless you all

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List of abbreviation

CB	Crown Base
CD-Block	Community Development Block
dbh	Diameter at breast height (1,3 m)
DFO	District Forest Officer
drc	Diameter root collar
FD	Forest Department
Ind.	Individual
JFM	Joint Forest Management
JFMC	Joint Forest Management Committees
KV	Kadavakurichchi Reserved Forest
MFP	Minor Forest Products
MSL	Mean See Level
N.-Ind.	Non-Individuals
NGO	Non Governmental Organisation
NTFP	Non Timber Forest Products
NTTP	Non Timber Tree Products
PF	Protected forest
PHCC	Palni Hills Conservation Council
PRA	Participatory Rural Appraisal
RF	Reserved Forest
SFM	Sustainable Forest Management
TAP	Tamil Nadu Afforestation Program
UF	Unclassified Forest
VIP	Very Important Person
WS	Watershed

Summary

The forest history of India is characterised by a continuous process of forest loss in area and quality caused through various social, political and forestry factors. Today hardly 20% of the land surface is covered by forest of which only 60% show a crown cover above 40%. The forest is mainly influenced by people living in or near the forest through fires, timber and fuelwood utilisation as well as grazing. This strong pressure which the Indian forests have to face makes the development of broad concepts for a sustainable management necessary. Experts agree that this is only possible with the involvement of local forest dwellers, not only in the planning of the forest utilisation as such but equally so in participating in the benefits of the forest products. But there are almost no studies that provide information about the relationship between the different kinds and intensities of forest use, its socio-economic background and its influence on the forests. That concerns mainly areas at low altitudes where 66% of the Indian forests are situated.
The present study tries to contribute to fill this gap. It aims to demonstrate the connection of the socio-economic background of forest users with the utilisation of the forest itself and to explain the forest structure as a result of the kind and intensity of use.

The study area, about 40 km² in extent, is situated at the foot of the Palni Hills, Tamil Nadu (South India) and includes a Reserved Forest of 10 km² and 19 adjacent villages. The forest is situated on the Kadavakurichi, a small hillock in the centre of the study area with a maximum altitude of 708 m above sea level. In order to evaluate the relationship between practised forest use and the condition of the forest, the study area was divided into five sub units (watersheds, WS's) which differ in the intensity of forest use. Each watershed comprises a part of the Reserved Forest as well as the villages next to it.
To analyse the vegetation, 500 sampling plots (30 m² for trees and 9 m² for the other vegetation) were demarcated in an even grid pattern covering the entire forest. Besides site parameters like elevation, slope, exposure, depth of soil and soil texture, the following parameters were selected to describe the vegetation: the number of individuals, height, diameter at root collar, area covered by the crown for trees and shrubs and for the entire vegetation the number and coverage of the plant species. Traces of browsing, chopping, fire and signs of trampling and cattle dung were also noted. In addition, a small forest around a temple (Temple Forest) 0.15 ha in size on the eastern slope of the hillock was surveyed. This little wood showed well developed, less disturbed vegetation.

The Kadavakurichi RF, with an average of 758 mm annual precipitation over the last 100 years, falls into the range of the Dry Deciduous Forest as well as the Tropical Thorn Forest. This amount of precipitation is only slightly below the amount of rainfall denoted for the Dry Evergreen Forest.
The structure of the forest as well as the observed damages on the plants indicates strong degradation. The Kadavakurichi Reserved Forest consists of thorny scrub averaging two meters in height with patches of tree savannas up to pure grasslands, which are kept open through annual fires. Within the 500 plots, 149 species were found of which the major part (31%) were trees. Trees covered also a third of the forest area and, therefore, it fits the classification of "open forest" as set by the Indian Government for 10-40% crown density. Even though they covered a relatively small area, they numbered 1223 pieces per hectare

with an average height of 2 meters and an average wood volume index[1] of 0.03 m³. *Commiphora berryi* and *Euphorbia antiquorum* were clearly the dominating species in frequency and coverage. They occurred in 68% and 55% of all plots respectively and were therefore more frequent than any other plant species. Shrubs were also an important part of the vegetation. They occurred in 73% of all plots and on average covered 12% of the area. The high ratio of grasses was striking. They were present in almost 70% of the plots and their coverage was on average 22% and therefore higher than the one of shrubs. 40% of the trees and 35% of the shrubs showed signs of damage with traces of chopping and burning being dominant. Signs of fire could be observed on the entire hillock.
In the Temple Forest the average cover of trees was almost 100%. Single individuals were up to 12 meters tall and showed a wood volume index of up to 3 m³. On the entire hillock no trees with similar dimensions could be found. The plants in the Temple Forest were only used to a small degree and only slightly injured.
A clear classification of the Kadavakurichi RF could not be established. It can be classified as a degraded form of the Dry Deciduous Forest as well as a degraded Dry Evergreen Forest. The composition of species in the Temple Forest indicates a high ratio of evergreen trees if development under low or non human impact takes place.

In order to collect information about the forest utilisation, apart from observations in the field, 222 structured interviews were carried out which represented 50% of the households involved in the collection of forest products. The interviews were held with the persons mainly involved in the product utilisation. The questions referred among others to caste affiliation, employment, gender, used product, used species, frequency and intensity of utilisation, shortages and alternatives in utilisation. To determine the differences in the socio-economic settings between the people involved in the forest product utilisation and the ones who are not, an additional fraction (10%) of households who did not depend on the forest were interviewed.
15% of all households in the study area collected products in the forest which were, in general, of great importance for the single household. Among the 19 different castes represented among all households questioned, the forest users claimed only 10 while more than 50% of the user-households belonged to the Mooper. Regarding the number and kind of livestock, the number of big herds of goats and sheep were higher among users while non-users showed a higher number of households owning cows. The two groups showed also differences in their occupations and unemployment. A higher ratio among the forest users were coolies (day labourer) and 62% were without income beside the one from the forest. In contrast the ratio of unemployed people among the non-users was 21%. The gender distribution did not conform to the usual assumption that women are mainly involved in the forest utilisation. In the study area men clearly dominated, while women outnumbered men only in the collection of a few minor products.

Extrapolated on all user households, 450 tons of fuelwood were collected ha^{-1} a^{-1} and this was therefor clearly the most utilised product. Second in importance was grazing. Other products like green manure, honey, medicinal plants and small timber played an inferior role.

[1] Calculated out of the length of the trunk and the area at root collar

The fuelwood was mainly collected in the forests of WS I, II and V while the utilisation in WS I and V was mainly conducted by people from WS I. The watershed with the lowest rate of fuelwood collection in its forest was WS IV. Half the fuelwood collectors stated, that the forest is their only source, but only 20% were not satisfied with the amount of wood they found.
The grazing pressure among the watersheds differed from the one of the fuelwood utilisation. Goats held the highest ratio among the grazed cattle and were mainly found in WS IV, I and V, while in WS III sheep clearly dominated. More than 40% of the herds men had no other pastures apart from the forest and more than 50% felt a shortage of fodder on the hillock.

Beside the utilisation of forest products, forest fires were another very important impact on the vegetation of the Kadavakurichi. The information about the extent and frequency of the fires was limited to the observation done by the author in the two year of data collection. During this time annual fires could be observed in WS I, II and III while WS I showed the biggest areas burned. In WS V fires occurred only occasional and in WS IV not at all.

Whether the different intensities of the forest use among the watersheds lead to a difference in the vegetation structure was tested with the help of regression models. In a first analysis it was tested to what extent the site determined the vegetation characteristics. As parameters for the vegetation structure the wood and crown volume of trees, the volume of shrubs and the volume of subshrubs and grasses were selected. With the help of a logistic regression model the probability with which the tested parameters appeared in dependency of the site factors was calculated. Subsequently the relation between the site and the characteristic of the selected parameters was tested with a linear regression.
Neither the occurrence of the tested parameters nor their characteristics could be explained through the site. The existing relation determined by the model as significant showed only a small explanatory power and all were caused through human activity in the forest. For example, the probability of the occurrence of trees declined with the elevation, while the volume of the grass layer increased. Both can be explained with the fires that were concentrated on higher elevations.

In a second step the watersheds, as categories of the intensity of human impact, were included in the model. Their explanatory power for the characteristics of the vegetation parameters was slightly higher than that of the site factors, but the results only partially correlated with the observed input on the watersheds. For instance the wood volume of trees in the Temple Forest was clearly higher than that in the watersheds, but did not match the watersheds in the different intensities of the extracted wood. In contrast to the related amount of utilised fuelwood, the model for WS I and V estimated very different wood volumes. In addition the model estimated for WS IV, where the highest values were expected on the background of the low impact, lower values than for WS V. The same applied for the crown volume of trees. The values for WS V where clearly above those of WS IV and the other watersheds, while the latter was exposed to the smallest wood collection and fire pressure.

That the affiliation of a fraction of the forest to a watershed only partially explain its vegetation structure has mainly two reasons. One can be found in the impact of the fires superimposing the effects of the remaining influences. This explains for example the difference in the wood volume of the watersheds I and V which, where frequented almost equally for fuelwood collection. This was due to the more frequent fires in WS I. Also the structure and composition of vegetation indicated the dominant influence of the fires. First of all, the depressive growth of trees and shrubs and the high ratio of shrubs, generally sprouting after fire, in WS I has to be mentioned. That the fire was present on the entire hillock is documented by the omnipresent fire traces. Therefore also areas like WS IV, where no fires occurred in the time of data collection, are affected.

A second reason for the low explanatory power of the watersheds for the vegetation parameters is the overlapping of the different kinds of utilisation in the Reserved Forest of the different watersheds. The impact on these sections could be determined, but not the one for the single plots as was possible with the site factors. A determination of the human impact on each of the 500 plots would have required exact information of the impact on this level which was not obtainable. This would have made long time observations necessary which require a large time frame and allow only a limited number of plots. In addition the vegetation in combination with the slow growth, even under unequal cutting and grazing pressure, differentiate only to a small extent, if at all. The development to a stage similar to the one of the Temple Forest was nowhere possible.

To determine the reasons for the forest fires is essential for their control and therefore for the forest management in total. Clear information about the reasons for the fires could not be obtained. On the basis of the interviews, in which the people had been asked about their opinion on the fire causes, and the observations done in the study period, the major motivation seems to maintain the accessibility of the forest and the killing of trees and shrubs for the utilisation of fuelwood. Beside this, religious and traditional motives seem to be important.

It was striking that almost none of the persons questioned thought that the fires were of benefit.

The urgent need to involve the fire in forest management strategies and the creation of the required political suppositions is expressed in the discussion of this paper. In the last chapter a zone-wise forest management with fire as an integral part is proposed. Specification about exact operation times and amounts of utilised products could not be given, because of the missing data for dynamism in the growth.

It become clear that for the development of the needed forest management system not only more knowledge about the vegetation development under various influences is required but also the reasons behind the forest fires and the effect of the fires on the vegetation have to be raised. This makes an intensive research in this field necessary.

Once this knowledge is available and an effort is made to implement it in the field together and in cooperation with the forest dwellers, forests like the Kadavakurichi RF do not have to remain thorny scrubs for long but could help to improve the life of the rural poor people.

Zusammenfassung

Die Waldgeschichte Indiens ist durch einen kontinuierlichen Prozess des Waldrückganges in Fläche und Qualität aufgrund verschiedenster Ursachen auf gesellschaftlicher, politischer und nicht zuletzt forstlicher Ebene geprägt. Heute sind knapp 20% der Landmasse Indiens mit Wald bedeckt von denen nur 60% einen Kronenschluß von über 40% aufweisen. Die Haupteinflussfaktoren auf den Wald sind Feuer, Bau- und Feuerholznutzung sowie Waldweide welche alle hauptsächlich von den im und am Wald lebenden Menschen ausgeübt werden. Der starke Nutzungsdruck, der auf den indischen Wäldern liegt, drängt zur Entwicklung von umfassenden Konzepten zur nachhaltigen Bewirtschaftung des Waldes. Die Fachwelt ist sich darüber im Klaren, dass eine nachhaltige Nutzung der Ressource Wald nur unter Beteiligung der den Wald nutzenden Menschen sowohl bei der Planung der Waldnutzung als auch bei den gewonnenen Waldprodukten möglich ist. Allerdings liegen kaum Studien vor, die Erkenntnisse über den Zusammenhang zwischen Art und Intensität der Waldnutzung und deren sozioökonomischen Hintergrund mit dem Waldzustand bereitstellen. Dies betrifft vor allem die Wälder in niederen Höhenlagen welche 66% der Wälder Indiens darstellen.

Die vorliegende Studie versucht hier einen Beitrag zu leisten. Sie hat um Ziel, den Zusammenhang zwischen sozioökonomischen Kontext der an der Waldnutzung beteiligten Menschen und der Waldnutzung darzustellen und den Waldzustand durch die Art und Intensität der Nutzung zu erklären.

Das ca. 40 km² umfassende Untersuchungsgebiet am Fuß der Palni Hills, Tamil Nadu (Süd Indien) schließt einen 10 km² großen Staatswald (Reserved Forest, RF) und 19 ihm naheliegende Dörfer ein. Der Wald befindet sich auf dem Kadavakurichi, einem kleinen Berg in der Mitte des Untersuchungsgebietes mit einer maximalen Höhe von 708 m ü. NN. Um die Beziehung zwischen ausgeübter Nutzung und Waldzustand herleiten zu können, wurde das Untersuchungsgebiet in fünf Untereinheiten (Watersheds, WS) eingeteilt, die sich hinsichtlich der Nutzungsintensität des Waldes unterscheiden. Jede Einheit umfasst einen Teil des Waldes und die Dörfer, die am nächsten liegen.

Für die Erfassung der Vegetation wurden 500 Probeflächen (30 m² für Bäume und 9 m² für die restliche Vegetation) in einem regelmäßigen Raster angeordnet. Neben standörtlichen Parametern wie Höhenlage, Hangneigung, Exposition, Bodentiefe und Bodenart wurden zur Beschreibung der Vegetation u.a. folgende Vegetationsparameter erhoben: bei Bäumen und Sträuchern die Individuenzahl, Höhe, der Durchmesser am Wurzelhals, Kronenschirmfläche, sowie bei der gesamten Vegetation die Anzahl und Deckung der Arten. Verbiss-, Schnitt- und Brandspuren der gesamten Vegetation sowie Spuren von Tritt und Viehdung wurden ebenfalls beschrieben. Zusätzlich wurde ein 0,15 ha großes Waldstück um einen Tempel (Tempel-Wald) auf der östlichen Seite des Berges erhoben, das sich durch eine geringe Nutzung und gut entwickelte Vegetation auszeichnete.

Mit 758 mm jährlicher Niederschlag im 100-jährigen Mittel liegt der Wald im Bereich des trockenen Laubfallwaldes (Dry Deciduous Forst) und des tropischen Dornwaldes (Tropical Thorn Forest) und knapp unter der angegebenen Niederschlagsmenge für den trockenen immergrünen Wald (Dry Evergreen Forest).

Sowohl die Vegetationsstruktur als auch die vorgefundenen Schädigungen zeigten eine Degradierung des Waldes an. Der Kadavakurichi RF bestand aus einem im Durchschnitt zwei Meter hohen dornigen Gestrüpp mit Übergängen von savannenartiger Vegetation bis zu durch Feuer offen gehaltenen Grasflächen. In den 500 Flächen befanden sich 149 Pflanzenarten von denen ein großer Teil (31%) Baumarten waren. Bäume deckten ein

Drittel der Waldfläche und somit fällt der Wald in die Kategorie des offenen Waldes, die von der indischen Regierung als 10-40 % Kronenschluss definiert wird. Es fanden sich 1223 Bäume je Hektar mit einer durchschnittliche Höhe von 2 Metern und einen durchschnittlichen Holzvolumenindex[2] von unter 0,03 m³. *Commiphora berryi* und *Euphorbia antiquorum* waren eindeutig die dominierenden Baumarten in Häufigkeit und Deckung. Sie kamen in jeweils 68% und 55% aller Flächen vor und waren damit häufiger als jede andrer Pflanzenart. Sträucher hatten einen bedeutenden Anteil an der Vegetation. Sie kamen in 73% aller Probeflächen vor und deckten im Durchschnitt 12% der Bodenoberfläche ab. Auffallend war der hohe Anteil an Gräsern. Sie waren in fast 70% der Aufnahmen enthalten und ihre Deckung lag im Durchschnitt mit 22% über der der Sträucher. 40% der Bäume und 35% der Sträucher wiesen Schäden auf, wobei Schnitt- und Brandverletzungen im Vordergrund standen. Brandspuren konnten auf dem gesamten Berg festgestellt werden.
Im Tempel-Wald erreichte der Deckungsgrad der Bäume fast 100%. Einzelne Individuen erreichten eine Größe von bis zu 12 Metern und einen Holzvolumenindex von bis zu 3 m³. Baumindividuen mit nur annähernd denselben Dimensionen konnten auch außerhalb der Aufnahmeflächen nicht gefunden werden. Die Pflanzen des Tempel-Waldes zeigten nur zu geringen Teilen leichte Schäden.

Der Kadavakurichi RF kann aufgrund der erhobenen Arten sowohl als degradierter trockener Laubfallwald als auch als eine degradierte Form des trockenen immergrünen Waldes angesehen werden. Die Artenzusammensetzung des Tempelwaldes lässt auf einen hohen Anteil immergrüner Baumarten bei ungestörter Entwicklung schließen.

Um Erkenntnisse über die Waldnutzung zu gewinnen, wurden neben Beobachtungen im Wald strukturierte Interviews mit der Hälfte den Wald nutzenden Haushalten, anteilsmäßig verteilt auf die verschiedenen Watersheds durchgeführt, was 222 Interviews ergab. Befragt wurde die Person aus dem Haushalt, die hauptsächlich an der Waldnutzung beteiligt war. Die Fragen bezogen sich unter anderem auf die Kastenzugehörigkeit, die Arbeitslosigkeit, das Geschlecht, die genutzten Produkte, die genutzten Pflanzenarten, die Häufigkeit und die Intensität der Nutzung, die Verfügbarkeit und Verwendung der gesammelten Produkte und die Alternativen für ihre Gewinnung. Um zu ermitteln, ob die den Wald nutzenden Menschen sich in ihren soziodemographischen Eigenschaften von denen, die den Wald nicht nutzen, unterscheiden, wurde zusätzlich eine anteilsmäßig kleine Stichprobe (10%) aus den Wald nicht nutzenden Haushalten befragt.
15% der im Untersuchungsgebiet angesiedelten Haushalte sammelten Produkte im Wald wobei die Nutzung für den jeweiligen Haushalt in der Regel von großer Bedeutung war.
Von den 19 Kasten die unter den befragten Haushalten vertreten waren, entfielen auf die Waldnutzer nur 10, wobei die Moopar den deutlich höchsten Anteil hatten. Der Anteil von Haushalten mit großen Ziegen- und Schafherden war unter den Waldnutzern größer während die Haushalte, die den Wald nicht nutzen, häufiger Kühe besaßen. Unterschiede zwischen beiden Gruppen fanden sich zudem in der Verteilung der Berufe und bei der Arbeitslosigkeit. Die Waldnutzer waren zu einem größeren Teil Tagelöhner als die Nichtnutzer sowie zu 62% ohne Einkommen als dem aus der Waldnutzung. Dagegen lag der Anteil der Befragten ohne Beschäftigung bei den Nichtnutzern bei 21%.

[2]Volumenindex errechnet aus Stammhöhe und Stammfußfläche

Die Geschlechterverteilung entsprach nicht der üblichen Annahme, dass Frauen hauptsächlich die Waldnutzung ausüben. Die Waldnutzung wurde eindeutig vorwiegend von Männern betrieben. Frauen waren an der Nutzung beteiligt, dominierten aber nur bei wenigen Nutzungsarten.

Feuerholz war mit einer für das ganze Untersuchungsgebiet hoch gerechneten Nutzung von über 450 Tonnen im Jahr (470 kg ha^{-1}) eindeutig das wichtigste Waldprodukt. An zweiter Stelle stand die Waldweide. Andere Produkte wie Gründüngung, Honig, medizinischen Pflanzen und kleines Bauholz spielten eine untergeordnete Rolle.
Die Holznutzung wurde schwerpunktmäßig in den Waldanteilen von Watershed I, III und V ausgeübt wobei die Nutzung in WS I und IV zum großen Teil auf Menschen aus Watershed I zurückzuführen war. Der Wald in WS IV wurde nur wenig zur Gewinnung von Brennholz genutzt. Für die Hälfte der Feuerholzsammler stellte der Wald die einzige Brennholzquelle dar. Es war auffallend, dass trozdem nur 20% der Feuerholznutzer angaben, nicht genug Holz zu finden.
Die Nutzungsintensität durch die Waldweide unterschied sich von der der Feuerholznutzung. Hier zeigte WS IV gefolgt von WS I und V die höchste Frequentierung mit Ziegen. WS III wurde eindeutig stärker durch Schafweide genutzt. Über 40% der Hirten hatten keine andere Möglichkeit der Weide als den Wald und 50% empfanden einen Mangel an im Wald vorhandenem Viehfutter.

Neben der Nutzung der Waldprodukte stellten die Waldfeuer einen weiteren sehr wichtigen Einfluss auf die Vegetation des Kadavakurichi dar. Die Information über die Ausdehnung und Häufigkeit dieser Feuer beschränkt sich auf die Beobachtungen die während des zweijährigen Forschungsaufenthaltes gemacht wurden. Dabei traten in WS I, II und III jährlich Feuer auf wobei WS I die größten Brandflächen aufwies. WS V zeigt nur vereinzelt und WS IV keine Brandereignisse.

Ob die verschiedenen Nutzungszenarien der Watersheds Unterschiede in der Vegetation bewirken, wurde mit Hilfe von regressionsanalytischen Modellen untersucht. Zuerst wurde getestet, inwieweit der Standort die Ausprägung der Vegetation bestimmt. Als Vegetationscharakteristika sind das Holz- und Kronenvolumen der Bäume, das Volumen der Sträucher und das Volumen von Halbsträuchern und Gräsern ausgewählt worden. Mit einem logistischen Regressionsmodell wurden die Wahrscheinlichkeiten, mit der die untersuchten Vegetationsparameter in Abhängigkeit von Standortsfaktoren auftraten, berechnet. Anschließend ist mit einer linearen Regressionanalyse der Zusammenhang zwischen dem Standort und der Ausprägung der ausgewählten Vegetationsparmeter geprüft worden.
Weder das Auftreten der getesteten Parameter an sich noch deren Ausprägung konnten durch die Standortseigenschaften gut erklärt werden. Die von den Modellen als signifikant angegebenen Zusammenhänge gehen auf menschliche Aktivität im Wald zurück. So nahm z.B. die Wahrscheinlichkeit mit der Bäume auftraten mit der Höhenlage ab, wobei das Volumen der Grasschicht zunahm. Beides ist auf die in den höheren Lagen auftretenden Feuer zurückzuführen. Die gefundenen Zusammenhänge zeigten nur eine sehr schwache Erklärungskraft.
In einem zweiten Schritt wurden die Watersheds als Kategorien für die Nutzungsintensität in das Modell aufgenommen. Ihre Erklärungskraft in Bezug auf die Ausprägung der Vegetation lag etwas höher. Die Ergebnisse stimmten aber nur zum Teil mit den vorliegenden Nutzungsgradienten überein. So ist zwar das Holzvolumen der Bäume im Tempel-Wald eindeutig höher, korreliert unter den Watersheds aber nicht mit der Intensität

der Holznutzung im Wald. Entgegen der relativ ähnlichen Intensität bei der Nutzung von Feuerholz schätzt das Modell für WS I und V stark unterschiedliche Holzvolumenindizes. Ebenfalls waren aufgrund der sehr geringen Nutzungsintensität in WS IV die höchsten Werte zu erwarten, blieben aber unter denen von WS V.

Die schwache Erklärungskraft der Nutzungsintensität für die Vegetationsausprägung hat hauptsächlich zwei Ursachen. Die eine muss in der die anderen Nutzungsarten überlagernden Wirkung des Feuers gesehen werden. So kann das unterschiedlich hohe Holzvolumen der Bäume in den ähnlich stark für Feuerholz genutzten Watersheds I und V durch das unterschiedlich starke Auftreten von Bränden erklärt werden. Auch die Zusammensetzung der Vegetation deutet auf das Feuer als bestimmenden Faktor für die Vegetation hin. Hier ist vor allem der depressive Wuchs holziger Pflanzen und der hohe Anteil an Sträucher, welche in der Regel auf Feuer folgen, in WS I zu bemerken. Dass der Feuereinfluss auf dem gesamten Berg besteht, zeigen die weit verbreiteten Brandspuren. Es sind somit selbst die Regionen vom Feuer betroffen, in denen während der Zeit der Datenerhebung kein Brand festgestellt wurde. Dazu kommt, dass sich eine Differenzierung der Vegetation unter der gleichmäßigen Beeinflussung durch das Feuer und dem langsamen Wuchs, auch bei einer unterschiedlichen Holznutzung oder Beweidung nur sehr langsam oder gar nicht einstellt. Die Entwicklung bis zu einem dem Tempel-Wald ähnlichen Stadium war an keiner Stelle möglich.
Eine zweite Ursache für die schwache Erklärungskraft der Watersheds für die Vegetaionsstruktur ist die Überlagerung der Nutzungen in den jeweiligen Waldanteilen. Der Nutzungsdruck auf diese konnte bestimmt werden, aber nicht der auf die einzelnen Aufnahmeflächen, wie es für die Standortsfaktoren möglich war. Ein flächenweiser Bezug des menschlichen Einflusses auf die Vegetation hätte genaue Informationen über die Nutzung auf der erhobenen Fläche vorausgesetzt, welche nicht zu erhalten waren. Dies hätte Langzeitbeobachtungen jeder einzelnen Fläche bedingt, was wiederum nur bei genügend Zeit und bei nur einer geringen Anzahl von Flächen möglich ist.

Die Gründe für die Waldfeuer zu bestimmen, ist grundlegend für ihre Steuerung und somit für die gesamte Waldbewirtschaftung. Eindeutige Hinweise auf die Ursachen der Feuer konnten allerdings nicht gewonnen werden. Aufgrund der Interviews, die die Frage nach den vermuteten Ursachen einschlossen, und der im Erhebungszeitraum gemachten Beobachtungen scheint das Offenhalten des Waldes zu Nutzungszwecken und das Abtöten der Bäume und Sträucher für die Feuerholznutzung im Vordergrund zu stehen. Daneben scheinen religiöse und tradierte Beweggründe von Bedeutung. Erstaunlich war, dass kaum jemand unter den Befragten das Feuer für nützlich hielt.

Die dringende Notwendigkeit der Einbindung des Feuers in die Waldbewirtschaftung und die Schaffung der politischen Voraussetzungen dafür, wird in der Diskussion der Arbeit dargelegt. Im letzen Kapitel wird eine zonenweise Waldnutzung unter Einbeziehung von Feuer vorgeschlagen. Genaue Angaben über Eingriffszeitpunkte und Entnahmemengen können aufgrund der fehlenden dynamischen Größen für die Waldentwicklung unter unterschiedlicher Nutzung nicht gemacht werden.
Die Studie macht deutlich, dass zur Entwicklung von Waldnutzungsverfahren, die das Feuer als zentralen Bestandteil beinhalten, sowohl die Beweggründe der Feuer als auch die Auswirkungen des Feuers auf die Vegetation bekannt sein müssen. Das macht eine intensive Forschung auf diesem Gebiet notwendig.
Darüber hinaus ist die Gewinnung von Erkenntnissen über die Entwicklungsdynamik des Waldes unter verschiedenen Nutzungsarten und –stärken unabdingbar.

1 Introduction

1.1 Background

Forests have been and still are today, one of the most important resources for mankind. It is not only its function as a basis for the world's climate as we find it today and on which we depend, that gives the forest its importance, but also the services and supply of a lot of forest products for the man's daily needs.

Several authors within forest science dealing with tropical forestry have described the role of man in this context. HESMER (1986) for example mentions, beside cattle, wood utilisation and agricultur, forest fires as the main factor of forest destruction and degradation. The consequences on the forest can be taken from several reports such as the "World Resources 1994-1995" from the World Resources Institute (VOGL, HEIGL & SCHÄFER 1995) and the actual "State of the world's forests" published by the FAO.

According to the FAO (FAO 2001), earth has lost 9.4 million hectares of its forest cover between 1990 and 2000 annually. While the forests in the so-called "developed world" have increased by about 29 million hectares in the last decade the "developing" countries lost 123 million hectares during this period. That is almost 10 % of the total forest cover of these countries. The World Resources Institute supposes that the area of degraded and fragmented forest is much bigger than the completely deforested areas (VOGL, HEIGL & SCHÄFER 1995). The institute estimates that this will lead to a much faster loss of forest ecosystems and biodiversity than the deforestation data can show.
In India "most of the forest areas in the country are ecologically in various stages of retrogression" (GOVERNMENT OF INDIA 1999). The reasons for this situation are complex. There are parameters which have a direct influence like land clearance for agriculture, fire, "excessive fuelwood collection" etc. as well as indirect parameters like economic under-development, inappropriate institutional systems, lack of land-use planning and others (GOVERNMENT OF INDIA 1999).
This phenomenon has, beside others, one main reason: "poor management of ecosystems" (BERKES & FOLKE 2000, FAO 1999). SINGH (1992) points out that the "wasteful utilisation" of India's forests is the cause of its low estimated stocking of 67 m^3 wood/ha^{-1} and an annual growth rate of only 0.7 m^3/ha^{-1}. The latter ranges from 3.85 m^3/ha^{-1} at the Western coasts to 0.41 m^3/ha^{-1} in the dry forest of the Indus plains (SINGH 1992, LAL 1992).
This situation is far from a sustainable management as defined by the Resolution H1 of the Second Ministerial Conference on the Protection of Forests in Europe 1993: "….sustainable management means the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems".
In order to change the situation and to come closer to a sustainable management of the forest in the tropics, specialists in the field of forestry increasingly call for the integration of local socio-economic realities and the accumulation of knowledge for the development and implications of sustainable patterns of forest management (HESMER 1986, VIEGAS &

MENON 1989, FERNANDES 1996, SEELAND 1997, MOSANDL & FELBERMEIER 2001 and others).

Without the knowledge of the forest and the patterns of its use it is not possible to reach this goal. This needs a description of the actual forest on the one hand and an analysis of its socio-economic background and the interaction of both factors on the other.

In a general way the forest types of India are described in the publications of CHAMPION (1936), LEGRIS (1963) and CHAMPION & SETH (1968). For some forest types in the South of India research was carried out by MEHER-HOMJI (1963, 1967, 1977), BLASCO (1971), LEGRIS & BLASCO (1974), PASCAL (1988) and PASCAL & RAMESH (1992). These publications describe the human impact on different forest types briefly, but an evaluation of the forest characteristics as a result of human impact goes beyond the scope of these works.
A more precise but still general description of the development of some forests in Southern India under human pressure can be found in BLASCO (1983) and PASCAL (1986).
Studies describing the dynamics and differences in relation to the varying intensity of human impact combined with an evaluation of the socio-economic situation as a part of a management plan are rare. BAJAJ (1992) has done a calculation on the basis of forest cover and population data regarding the needed increment of per capita forest to effect an improvement of the forest cover. Other studies in neighbouring countries of India have been done by KHATTAK (1992) in Pakistan and GIESCH (2000) in Bhutan, within India by KOTRU (1993) in the Northwest Himalayas and OSTWALD (2000) in Orissa. All of these works include a forest inventory and an evaluation of the socio-economic situation leading to suggestions for a sustainable forest management. PYRAVAUD et al. (year unknown) carried out a similar study in Karnataka but without the socio-economic component. Almost all of these studies have been carried out in mountain areas on higher elevation. But 66% of the Indian forests are estimated to be situated in elevations below 600 meters (GOVERNMENT OF INDIA 1999). Only little is known about these forests.
The lack of reliable information and concepts of forest management is striking considering that decision makers in politics and forestry became aware of the problem more than 20 years ago which lead to the introduction of social forestry schemes (AGARWAL & SAIGAL 1996, POFFENBERGER et al. 1996a, FERNANDES 1996, THINAGARAN et al. 1999, CONROY 2001). Especially the implementation of Joint Forest Management in 1990 (SÜSS & SEELAND 1996, AGARWAL & SAIGAL 1996, CONROY 2001) should force the analysis and solution of forest utilisation patterns. "There is an urgent need to understand the relationships between resource degradation and social unrest…." (POFFENBERGER et al. (1996b, p.17) especially against the background of the great diversity of India's forest dwellers and forest types.
This study not only wants to contribute to the knowledge about the forests on the plains of southern India and its response to the influence of traditional forest uses. It also aims to understand the people using these forests, their pattern of resource management and their economic situation. On the basis of this an outlook of the further management of these forests regarding sustainability shall be given. For carrying out the research a Reserved Forest located on the Kadavakurichi hillock in the centre of Tamil Nadu, India's most southern state was chosen.

1.2 Aims, objectives and hypotheses of the study

The aim of this study is to account for the forest use by the population, the impact of this use on the vegetation of the Kadavakurichi Reserved Forest and an evaluation of sustainable patterns of forest use. To show the connection between the forest structure and the people's patterns of forest use, five different sub-units of the area (watersheds), with different intensities of human impact on their part of the RF, are presented and compared.

The objectives of the study are:

- Analysis of the structure of the forest vegetation in the study area
- Account of the present forest management, forest products in use and the intensity of the forest utilisation in the context of Indian forestry
- Assessment of the impact of different forest uses and their intensities on the structure of the forest
- Account of the social status of the forest users and their dependency on the forest
- Reflections on a sustainable forest management

For the analysis of the relationship between the forest users and the forest vegetation hypotheses were formulated. It is important to prove the influence of natural site factors on the structure and composition of the vegetation first, to distinguish it from the human impact. For this the following hypotheses was set up:

H_1: There is no significant correlation between the site factors and the vegetation features.

In the context of extensive human use of the forest it seemed to be likely that the development of the vegetation is an anthropogenic rather than a site effect. To test this, a second hypotheses was formulated:

H_2: There is no correlation between the intensity of the forest use by the local forest users and the vegetation features.

The hypotheses are formulated negatively to fulfil the criteria of refutability (POPPER 1994 pp. 39). The reason is that a positively formulated hypothesis could perhaps not be rejected, even though it cannot be confirmed.

1.3 Structure of the study

In the following chapter, the situation of the forests in India, their history and present utilisation, with special reference to Tamil Nadu will be given. Joint Forest Management (JFM) as the actual way of participation of local forest users in the forest utilisation shall be focused on. A subchapter will be dedicated to forest fires, which play a key role in the utilisation of India's forests.

Chapter three gives an account of the study area. The natural as well as socio-economic conditions of India and Tamil Nadu in particular are described. Chapter four contains the methodology used for raising and analysing the data as well as the formulation of the hypothesis, which forms the background of the analysis. Chapter five first gives a descriptive analysis of the socio-economic and forests inventory data. In the second part the hypotheses are tested with statistical methods. In chapter six the results are discussed in terms of a change in the forest management and in chapter seven some perspectives for a sustainable use of the Kadavakurichi Reserved Forest are shown.

2 Forestry in India and Tamil Nadu

The situation of forest utilisation in the study area can only be understood on the background of the all Indian context. In this chapter it will be shown, how over history in the connection of man and the forest the forest cover has been constantly reduced under increasing pressure and demand of forest products. The use of forest products today surpasses, according to the official data, the growth of the forest and thus the loss of forest in cover and quality continues. A vital role in this context is played by forest fires and the standard of knowledge about their extent and causes are described. The last part of this chapter will view the programs of the Indian government to solve the problems, which focused mainly on the involvement of the local forest dwellers.
As the study area was in Tamil Nadu, the different issues relevant for this state shall be described separately at the end of this chapter.

2.1 Forest history abstract

It can be assumed that India has been covered with dense forest from at last one million years ago right up to historic times (STEBBING 1922, SPATE & LEARMONTH 1967 in ERDOSY 1998). According to MALONEY (1975) and CHOPRA et al. (1979) the earliest man in South India could be dated to 400000 years ago. But very little is known about forest utilisation and its influence on the vegetation in pre-colonial times. GOLDAMMER (1993) assumes that the dry- and monsoon forest of Asia has been affected by man's action for 12000 years. CHANDRAN (1997) date a significant vegetation influence for the Western Ghats 8000 years later when man became settled. Slash and burn was the major practice to create agricultural land in the forest, starting the change in the climax vegetation (CHANDRAN 1997).
After the invasion of the Aryans into India around 2000 BC the pressure on the forest increased slowly. But still the change in the forest was hardly visible for the next centuries. Alexander the Great found dense forest when he crossed the Himalayas in 327 BC to the North of the Punjab "in spite of this being the part of the country where the Aryan invaders first developed a stable government" (STEBBING 1922 p. 30). Out of this time a controlled forest utilisation in North India under the Gupta kingdom (320 to 800 AD) is reported. It involved a classification of forests, employment of foresters and rules for the protection and utilisation (PANDE & PANDE 1991). The forest destruction increases according to STEBBING (1922) under the constant invasion of people from Central Asia who had herds of cattle with them, slashing and burning the land in order to create grazing ground. This development found its peak under the reign of the Muslims from 800 AD onwards, under which the "original agricultural population were driven back into the forests" (STEBBING 1922, p. 31). Here they practised shifting cultivation and used the forest as a source of raw material, agricultural land and grazing ground. In addition the forest had to satisfy the Roman Empire's demand for Indian Ebony, Teak, Sandalwood and Eagle-wood and between 500 and 1500 AD that of several other Asian countries (BOOMGAARD 1998).

According to STEBBING (1922) the methods of timber harvesting in the pre-British period were extremely wasteful. “The felling carried out to supply these requirements were in the hands of bands of timber merchants, who readily obtained short leases from local officials in charge of the localities, or from those who claimed the ownership of the forest, and felled the big timber and any smaller material that had a sale, destroying all young growth of every description by the reckless methods of extraction employed” (STEBBING 1922 p. 35).
At the beginning of the British period these practices were even worse[1]. The British took over the system of timber harvesting through merchants but under a tremendously increasing demand for wood for military purposes, export, railway sleepers in addition to a fast increasing population (BRANDIS 1897, STEBBING 1922). This opened the forest for the local population who settled and used the forest (GADGIL 1991).

That this practice lead to a shortage of timber and the destruction of the forest resources is obvious and all authors point this out clearly (BRANDIS 1897, FRANCIS 1906, STEBBING 1922, HESMER 1986). The need for change was realised and put in practice locally but a regular forest management started only with the appointment of Dr. Brandis, a botanist from Germany, as the head of the forest administration of the Burmesian province Pegu in 1856. One year later he was in charge of all forests in Burma. Under his influence the Burmesian teak forests were managed according to management plans and the teak economy of Burma developed into a sustainable and lucrative business (HESMER 1986). Because of his success Brandis was appointed the first Inspector General in India on the 1st of April 1864 following the passing of the first forest Act in 1862. He stayed in this post until 1883.
As early as 1865 a new Forest Act was passed which regulated the constitutions of government forest and the issue of forest orders through the provincial governments (HESMER 1986, DAWKINS & PHILIP 1998). Brandis’ main objective in the beginning of his incumbency was to start the exclusion and marking of forests reserved for the government, protection of these forests from fire, illegal felling and grazing, and the organisation of the forest administration (MAMMEN 1964, HESMER 1986). The protection system found its legal base in the Forest Act of 1878 which contained as one of the most important points the definition of “Reserved Forests”. They had to be demarcated immediately and put under management plans for the production of timber according to silvicultural methods. Customary rights where abrogated (HESMER 1986). Another category of forest was the “Protected Forest”, which were intended to be temporarily under protection until a management could be implemented. In order to regulate the rights of local people, the Act also defined village forests, which should be used but not above the level of their productivity. The implementation was difficult due to the suspicion of the villagers themselves (DAWKINS & PHILIP 1998).
The area that came under protection increased tremendously in the following decades. In 1898 21 million ha were already counted; this increased to 26.7 million ha in 1914. In 1899 two fifth, that is 5.2 million ha, of the RF were managed according to working plans and in 1920 the area almost trebled (HESMER 1986).

[1] For an impression on the trade between India and Europe under the Dutch and British rule with reference to single valuable timber species see BOOMGAARD (1998)

But this did not mean automatically that the deforestation stopped or that the forests even recovered. The forest quantity and quality started decreasing in 1911 after the responsibility for forest revenues and expenditures were shifted from the Government of India to the provincial governments. Shifting cultivation in reserves was allowed and limits on rights over unclassified land were lifted. Over grazing and over cutting took place and led to shortages in fuelwood supply. The forest classification changed and forestland was given to local communities and by 1928 20% of the forests were handed over as panchayat (or local) forests (DAWKINS & PHILIP 1998).
After the Second World War the state of forests in private ownership was worse. Besides acts that were passed by provinces to allow the forest departments to intervene in private forestland (DAWKINS & PHILIP 1998) large private forests were taken under the control of the forest administration after independence (GOVERNMENT OF INDIA 1999). Thus the recorded forest area increased from 40 million ha in 1947-48 to 75 million ha in 1986-87 (FOREST SURVEY OF INDIA 1987). Illegal felling by former owners made a strict protection necessary. In private forests, heavy felling by the owners set in to gain benefits before ownership was surrendered. The forest also had to suffer under the fast development of forest dependent industries, the construction of new railways and roads. The demand of a growing human and domestic animal population also led to a large-scale utilisation of fuelwood, fodder, food, medicine and small timber. In addition nearly 4.3 million ha of forest came under agricultural use. In 1995 good forest with a crown density of more than 40% covered only 11.73 % of the land area.

2.2 Forestry today

2.2.1 Forest Cover

Today some 76.52 million ha (23% of the geographical area) are recorded as forest land which is classified in three classes of protection:

<table>
<tr><td>Reserved Forest (RF)</td><td>Full protection. All activities are prohibited unless permitted.</td><td rowspan="2">Notified under the provisions of Indian Forest Act or State Forest Acts</td></tr>
<tr><td>Protected Forest (PF)</td><td>Limited protection. All activities are permitted unless prohibited</td></tr>
<tr><td>Unclassed Forest (UF)</td><td>Ownership status of such forest varies from state to state</td><td>An area recorded as forest but not included in reserved or protected forest category.</td></tr>
</table>

Tab. 2.1: Classification according to the status of protection of recorded forest (Forest Survey of India 1999)

The RF constitutes 55% of Indian forest, while the PF and the UF hold 29% and 16% respectively. The actual forest cover is less than the recorded forest area. Defined as areas with a crown cover density of more than 10 % (table 2.2) it covers slightly more than 19% of the geographical area.

Class	Area in km²	Percentage of Geographic area
Dense forest (Crown cover density > 40%)	377,358	11.48
Open Forest (Crown cover density 10-40 per cent)	255,064	7.76
Mangrove	4,871	0.15
Total	**637,293**	**19.39**
Scrub	51,900	1.58

Tab. 2.2: Forest cover in India (FOREST SURVEY OF INDIA 1999)

Only 60% of the forests have a crown density above 40% and out of this only 10% have a crown cover above 70% (GOVERNMENT OF INDIA 1999). The forest cover within India varies a lot.

The forests are concentrated on the Western Ghats and the areas West of them, in the Middle West, in the Himalayas in the North and in the extreme North West. According to this distribution, the forest cover varies among the different states. Arunachal Pradesh in the North West has for example 82% of its geographical area under forest while Haryana and Punjab do not exceed 3 % (fig 2.1).

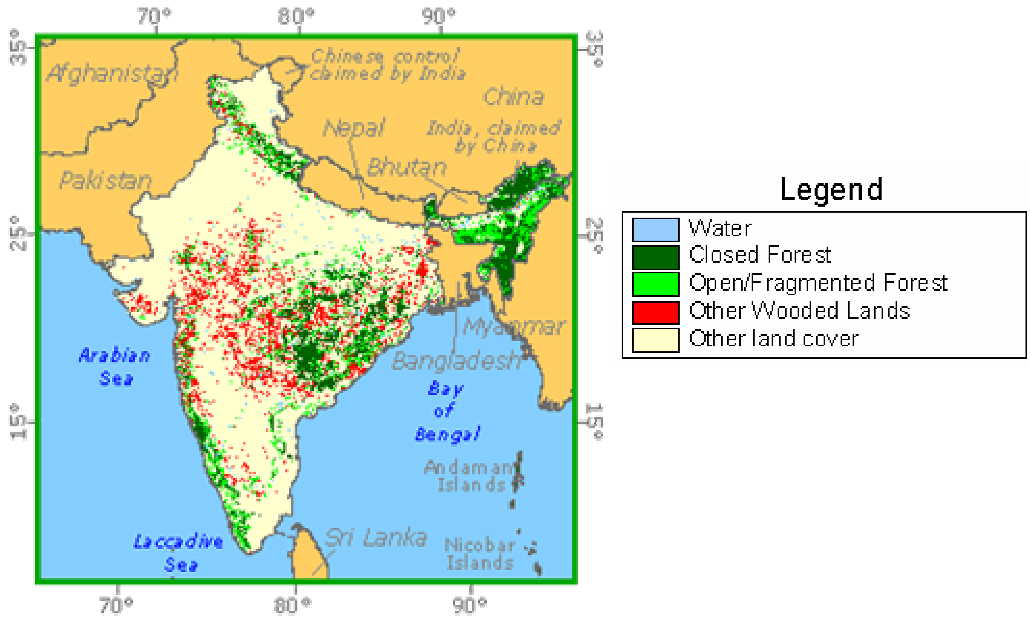


Figure 2.1: Forest distribution in India (source: FAO 2002)

Most of the forests in India are found in lower areas. The GOVERNMENT OF INDIA (1999) estimates, that around 66 % of the forest are located at elevations lower than 600 meter.
The different climatic and geographical conditions of the country cause a broad diversity among the forest types, ranging from dry forest to alpine forest types (see chapter 3.3.3).

2.2.2 Growth and utilisation

The demand for different forest products is high. According to the GOVERNMENT OF INDIA (1999), the forest nearly meets 40 % of the country's energy needs. If the commercial need is excluded it is even 80% (RAI & CHAKRABARTI 1996). An amount of 270 million tonnes of fuelwood[2], 280 million tonnes of fodder, more than 12 million m³ timbers and "countless Non Wood Forest Products" are extracted from India's forests annually. (GOVERNMENT OF INDIA 1999). On the basis of the actual forest cover and if the ton is taken as equivalent to a cubic meter, 4.43 m³ of fuelwood and timber are extracted per ha annually.
The increment of wood in India's forests is estimated by the Indian Government to be 87.62 million m³ containing 52.62 m³ timber and 35 million m³ fuelwood.
Divided by the area under forest, this gives an annual growth of 1.4 $m^3\ ha^{-1}\ a^{-1}$. Thus the demand for wood (timber and fuelwood) is four times higher than what can be removed from the forest in a sustainable way. With a growing stock of 74 $m^3\ ha^{-1}$ (GOVERNMENT OF INDIA 1999) and an annual growth of 1.4 m³, wood in Indian forests grows at a rate of 2 % of the stock. But this is a more optimistic estimation compared to 0.7 $m^3\ ha^{-1}\ a^{-1}$ (1%) given by SINGH (1992) and LAL (1989).

[2] 297 million m³ in the year 2000 (FAO 2000)

If the production and the consumption are now put together against the background of the growing stock, the Indian forests would vanish within the next two decades. This seems to be an unrealistic scenario. For a calculation of the loss of growing stock, it shall be assumed that half of the utilised wood allegedly coming from forests originates from other sources like fields and wasteland. If the growing stock is taken as actual and the used amount of wood is expected to stay constant, the following picture develops for the future of the growing stock for the different growth rates:

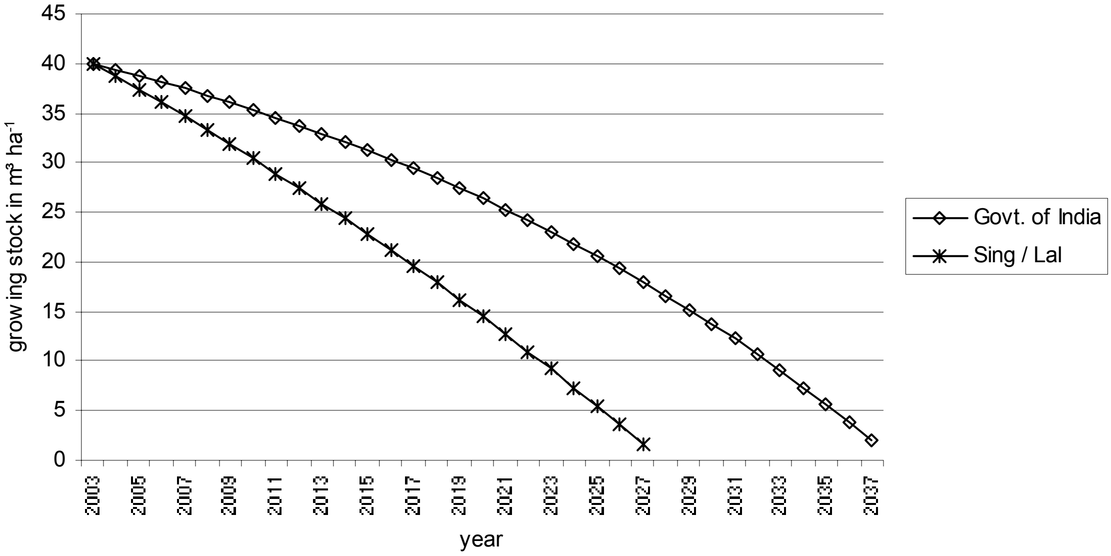


Fig.2.2: Development of growing stock per ha for different growing rates

Figure 2.2 indicates that on the basis of the official data the forests of India will be gone by the middle of this century at the latest. All data included in this calculation are very imprecise. It is also unaccounted if and how the utilised amount varies under decreasing forest resources. Thus this figure cannot be taken as an exact forecast but as an outlook on the development of India's forests in the future.

In contrast to timber and fuelwood, which are considered as "major forest products", other forest products like fodder, leaves, flowers, seeds, resin, bark, honey etc are described as Non Wood Forest Products (NWFP) or Minor Forest Products (MFP)[3]. Their importance in the utilisation of India's forest is often expressed (TROUP 1907, POFFENBERGER 1996, MAHAPATRA 1997, BUCHI 1997, GOLDAMMER 1988, GOVERNMENT OF INDIA 1999 among others[4]).

MUTHIAH (1987) gives a NWFP produce of 851 million Rs (today around 17 million US$) for India of which Madhya Pradesh produces almost half. POFFENBERGER (1996) points out, that nearly 60 % of all recorded forest product revenues in India come from NWFP and that most of India's tribal people depend on this product for their income. The impact on the forest varies much by the product used and the method of utilisation. If fire is involved, which is often the case (see chapter 2.4.4), the damage can be considered as formative.

[3] other terms are Non Timber Forest Products (NTFPs) and Non Timber Tree Products (NTTPs) (POFFENBERGER 1996)

[4] see also: SHIVA & MATHUR (1990)

One of the intensively used products in this category is fodder. Here, also, the demand exceeds the production. According to SINGH (1994 in RAI & CHAKRABARTI 1996), forestland provides 2 tons ha^{-1} a^{-1} dry fodder, which gives around 127 tons for the entire forest area in India. From the data on green fodder given by the same author another 84 million tons have to be added. This sums up to 210 million tons of fodder growing in India's forest annually. But around 280 million tons are removed (GOVERNMENT OF INDIA 1999). That this leads to a loss of forest in area and quality seems obvious.

2.2.3 Deforestation and Degradation

Various national and international institutions like the FAO, the World Bank and the Forest Survey of India give figures about the loss of forest in India. But the information varies according to the data on the actual forest cover in use. Therefore, here it will be referred to the report of the GOVERNMENT OF INDIA (1999) will be referred to because it's authors included different sources in their estimations.
Regarding the changes in the area under forest it is stated, that the loss of natural forest from 1980 to 1995 was 4.74 million ha. That is 7.4 % of the total forest area. In the same time period the area under plantations increased by about 6.74 million ha leading to an overall increase of the forest area. However, these plantations do not replace the natural forest in diversity of species and products and in addition the remaining forests, natural as well as plantation, are constantly losing quality. This degradation is another serious matter.

The definition of the FAO (2000) considers the importance saying, "in most cases, degradation does not show as a decrease in the area of woody vegetation but rather as a gradual reduction of biomass, changes in species composition and soil degradation". To put the degradation in reliable data is therefore difficult and the existing data do most likely not represent the full impact. The FAO (1998 in OSTWALD 2000) for example say that 2.3 % of India's forests were affected by degradation from 1980 to 1990. Regarding the change in the cover class, the FOREST SURVEY OF INDIA (1999) gives the recent development: Between 1997 and 1999 the area under dense forest increased by almost 3% and the one under open forest declined by about 2.3 %. But these data do not distinguish between natural forest and plantation and give no information about the forest condition.

The figures regarding the change in forest cover consider the development for as long as data have been recorded. They don't contain the degradation that already took place during the history of India's forests. It can be assumed that most of them were once dense (STEBBING 1922, CHAMPION 1936). The actual crown density compared to the situation around 300 years ago gives an idea of the degradation that took place.

2.2.4 Forest fires

Fire is considered to be a major cause of forest degradation in India (BAHUGUNA 2002). It is stated, that around 90% of the Indian forest fires are anthropogentic (BRANDIS 1897, SAIGAL 1990, GOVERNMENT OF INDIA 1999, BAHUGUNA 2002 among others). Thus the effects, extent and motivation of forest fires shall be focussed on here.

The literature on the effects of fire on ecosystems is countless and gives a good picture of the impact of fires on soil and vegetation (LUTZ 1956, AHLGREN & AHLGREN 1960, SCHIMITSCHEK & JAHN 1961, JALALUDDIN 1969, DE BANO et al., 1967/1977, RUNDEL 1981, GOLDAMMER 1988, SCHMERBECK 1995 among others). The description of these effects shall be concentrated here on the dry forest of the tropics.

In Asia the development of the dry- and monsoon forests has been inseparably connected with fire for 12000 years (GOLDAMMER 1993). Under a high fire frequency, in addition to other human activities like wood utilisation and grazing, these forests turn into open forest communities, savannas and even grasslands (BLASCO 1983, MISRA 1983, COLE 1986, GOLDAMMER 1993). These vegetation types, according to GOLDAMMER (1993) termed as "Savannas", represent the major part of the natural and semi natural tropical vegetation of today (COLE 1986, GOLDAMMER 1993). This indicates that the transformation from forests to savannas is not a matter limited to some localities but a world-wide phenomenon.[5]

The situation in India does not differ from this fact or development. MISRA (1983) points out that the tropical sub humid and dry deciduous forests of India, which once covered the entire country, are almost completely replaced by savannas (see also COLE 1986) and CHAMPION (1936 p. 12) defines fire as the most dominant of all human influences on forests in India.

An exact evaluation of the fire frequency and intensity in India's forests does not exist (Goldammer 1993). BRANDIS (1897) estimated at the end of the 19th century that half to three quarters of the mature trees in the plains and lower hills of India were hollow through fire. "In this respect all deciduous forests in India suffer alike" (p.8). According to the GOVERNMENT OF INDIA (1999) 35 million ha of Indians forest (54%) are affected by fire annually. The proportion varies among the states between 33% in West Bengal to 93 % in Arunachal Pradesh.

The reasons why man uses fire in the forests are numerous. In the first place it is a tool in the management of many forest products. The traditional fire management aims to keep the vegetation in a productive stage and push back unwanted plant species (RENSBURG in GOLDAMMER 1993, KURIAN & SINGH 1996). This is for example practised in connection with forest grazing. Herdsmen burn the vegetation to keep it accessible and to stimulate the grasses to create fresh shots (BRANDIS 1897, GOLDAMMER 1993, GOVERNMENT OF INDIA 1999). Fire plays also a vital role in the creation of agricultural land through shifting cultivation. In this system a piece in the forest gets cut followed by burning of the

[5] For further information about the relationship between fire and savannas please see MISRA 1983, BLASCO 1983, HESMER 1986, CAHOON et al. 1992, GOLDAMMER 1993, ANDERSEN et al. 1998, HIGGINS et al. 2000 and others.

material[6]. The utilisation of further NWFPs is another important field of forest management with fire. Fires are used for the production of leaves from *Diospyros melanoxylon* and other tree species to manufacture Beedis, small Indian hand made cigarettes, and for the collection of flowers and fruits through burning the litter on the forest floor to make them visible (GOLDAMMER 1993, SAIGAL 1990). Fire was also used by the early inhabitants of the country for hunting (GOLDAMMER 1993) and still seems to be used for this purpose (BRANDIS 1897, LAMPRECHT 1986, GOVERNMENT OF INDIA 1999).

Beside the use of fire for the utilisation of forest products other motivations exist: In and around the studied area fire is set to cause rain through the smoke (see chapter 3.7 and 5.1.3). In the literature this is not mentioned for India, but GOLDAMMER (1978) reports similar observations from Mexico. KURIAN & SINGH (1996) found in a study on forest fire in Harayan where in some cases the forest was burned as protest against strict actions of the forest department against illegal forest use. Further motivation can be religious activities, fear and making fire for fun (GOLDAMMER 1993).
But often the reasons for the fires are not known and it is hard to discover them. This is not only because of lacking control, but also because of different interests in the forest and resulting conflicts in which different groups accuse each other of setting the fires as shown in a report from Uttar Pradesh (AHMED 1999).

Almost nothing is known about the proportion of the different causes for fire. Statistics for the Madras presidency, state that almost a third of the burned area in RF could not be explained for the year 1922, another third of the fires entered from outside the RF and almost half of the remaining third was caused by hunting ("in order to turn out game or to reduce cover") followed by starting a fire to cause new grass shoots (FOREST DEPARTMENT MADRAS PRESIDENCY 1922-23).
To get reliable data on the situation today is difficult, because the total number of fires in India is not known for any region (GOLDAMMER 1993). Even for the supposed major causes of grazing and shifting cultivation (SAIGAL 1990, GOLDAMMER 1993, GOVERNMENT OF INDIA 1999, BAHUGUNA 2002), only estimations about their ratio on the total number of forest fires are available.
What can be said is that the significance of the different reasons seems to vary strongly among different locations. In the study area and the surrounding hill ranges the utilisation of fuelwood seems to play a major role (see chapter 3.7 and 5.1.3) while KURIAN & SINGH (1996) found the clearing of agricultural fields after the harvest to be the main reason for forest fires. In the Tiruvanumalai Reserve Forest, North West of Chennai (Tamil Nadu), the fire serves the utilisation of grasses used as cow fodder and roof material, harvested through contractors (own observation).
But research on the different reasons for forest fires on a local basis in order to involve this main component of human impact on the forest does, even against the background of an increasing participation of local community in forest management, almost not exist.
The forest fire policy in India has not proceeded beyond fire protection as it was implemented by Brandis in 1864 (MAMMEN 1964). The National Forest Policy 1998

[6] For shifting cultivation please see LAMBRECHT 1986, GOLDAMMER 1993, CHANDRAN 1997, BUCHI 1997, THAKUR 1997 and GOLDAMMER 1988/1993.

(Singh 2000) mentions the high incidence of forest fires and requests “special precaution” and “improved and modern management practices” (p. 328). The accomplishments of this policy are limited to fire prevention and control. The Ministry of Environment and Forest implemented a plan called “Modern Forest Fire Control Methods” which provides financial assistance for several fire prevention and control activities based on better information flow and fire fighting equipment (SAIGAL 1990, BAHUGUNA 2002). The recruitment of local people in this policy is limited to the recruiting of local fire watchers and fighters.

These activities led locally to a reduction of the burned area (SAIGAL 1990) but a long-term effect can be doubted.

2.3 Joint Forest Management

Already Brandis was aware of the role local forest dwellers play in the forest utilisation and degradation. One of the aims he had as he started his work in the province of Pegu, was “to make the inhabitants of the forest and the people around them my friends and allies” (HESMER 1986). He implemented the consideration of local people and their cultures in the Forest Act of 1878, but this did not lead to a participation of the stakeholders in forest utilisation in the management and share of the products. The forestry in India was in the hand of the forest department with the attitude to abrogate forest rights and, in the first place to produce timber. The policy of the forest department could not establish a sustainable forest use and the deforestation and degradation went on. These problems not only existed in India but also in large parts of the tropics. It was recognised world wide through the United Nations Conference on Environment and Development in Stockholm 1972 and later in Rio de Janeiro 1992. The discussion about people participation in forestry found its worldwide acceptance in the 8th World Forest Congress held in Jakarta, Indonesia 1978.

In India the Government tried to fulfil the requirement of the rural population and to take the pressure from the RF with massive afforestation on public land outside the RF under the Social Forest Program of the seventies and eighties (ARGAWAL & SAIGAL 1996, SEELAND 1999). But success did not materialise in the expected way because of uncertainties regarding the rights to the different forest products, the willingness of the local population and the poor training of the FD staff in charge of the implementation of the program (SEELAND 1999).

The National Forest Policy of 1988 articulated the participation of the forest dwellers in the management of the Indian forests, called Joint Forest Management (JFM). The new forest policy said clearly: “The life of tribals and other poor living within and near forests revolves around forests. The rights and concessions enjoyed by them should be fully protected. Their domestic requirements of fuelwood, fodder, minor forest produce and construction timber should be the first charge on forest produce” (in SINGH 2000 p. 325). To implement this new policy and to underline the involvement of local people in the forest management the “Govt. of India guidelines for participatory forest management”[7] where issued in 1990 by the central government and sent to the Forest Secretaries of the States. This resolution envisages the participation of the FD, local forest user organisations

[7] No. 6-21/89-P.P, 1st June 1990 (SINGH 2000, p. 331)

and voluntary agencies / NGOs in the management of the forest but excluded a transfer of the ownership or right over forest land to the beneficiaries or the associated organisation.

The circular moved the state governments to issue legal basis for the implementation of JFM. Already in 1989 West Bengal started to issue the respective laws and after six years 16 states had followed (ARGAWAL & SAIGAL 1996). The terms and rules used for conducting the program vary slightly between the states but follow almost the same pattern: The selected village (panchayat) forms a committee that is in charge of the forest affairs coming up under the program. These committees are titled with various names in different regions and shall here, according to the usual term in Tami Nadu, be called Village Forest Council (VFC)[8]. Together with the FD and allied NGOs or other voluntary agencies, a Micro Plan will be conducted for a time span of five years in the frame of the working plan of the Forest Division (ARGAWAL & SAIGAL 1996, SEELAND 1999). While the working plan is designed for 10-20 years and forms the basis for the forest management in the Forest Division, the micro plan contains additional aspects regarding the need of the community. The VFC is formed out of villagers who elect an executive committee and a president who is the contact person to the FD. Ideally, the VFC represent all households of the village and both genders in the way they are involved in the utilisation of forest products. According to the "Guideline for strengthening of Joint Forest Management Program" (SINGH 2000, p. 335, see also footnote 8) 10.24 million ha in India (13% of the recorded forest area) were under JFM programs by January 2000 with the participation of 36075 VFCs.
Parallel to the official programs communities in East India already in the 1950's started to protect the forest that they were dependent on by themselves (ARGAWAL & SAIGAL 1996). The movement includes today an estimated number of 12000-15000 villages protecting one to two million ha of forest. (POFFENBERGER et al. 1996a). An inventory of these communities does not exist so that many of them remain unknown and are, in contrast to their importance for the forest, not recognised. They have the choice of continuing and remaining unrecognised, or to join the official programs and be in danger of losing the grown structures which they have evolved and possibly to collapse (POFFENBERGER et al. 1996a).

The question of the success of JFM is discussed controversially. The implementation of JFM, its acceptance and involvement in the forest management in several states is regarded positively (VARALAKSHMI et al. 1993, SARIN 1995, AGARWAL & SAIGAL 1996, VARALAKSHMI et al. 1993, CHAUDHURI 1996, SREEDHARAN & SARCAR 1998, THINGARAN 1999, KUMAR 2000, SEELAND 1999, others). But reports on the success as well as objective statistics, enabling a balance between input and output of JFM activities on state level or for the whole of India are rare. Success stories are mainly reported form Southwest Bengal. SARIN (1995) and POFFENBERGER et al. (1996a) mention the changes in the vegetation cover visible on satellite images. According to POFFENBERGER et al. (1996a) the area under dense forest increased in Southwest Bengal by about 14 % in only 3 years between 1988 to

[8] According to the Govt. of India Circular No. 22-8/2000-JFM (FPD) 21st February 2000 "Guideline for strengthening of Joint Forest Management Program" (SINGH 2000, p. 335) the committees in India should be uniformly called as Joint Forest Management Committees (JFMC) which seems a practical solution. But the location of the study area in Tamil Nadu makes the VFC a suitable term here.

1991. The author refers to studies, which show that in some forests the number of trees above 10 cm girth at breast height rose after 10 years from 0 to 961 per ha and refers to other authors who report similar results.
However, the functioning of JFM and its impact on the forest situation in India stays far behind the expectations. SÜSS & SEELAND (1996) mention a study in Rajastan where the contact between administration and VFC was limited to communication between FD and the VFC president while the VFC members remained uninvolved. Thus the villagers where not informed about their rights and responsibilities and where demotivated to participate.
AGARWAL & SAIGAL (1996) criticise that the planing and management is mainly in the hands of the FD and the micro-plans thus do not mirror the needs of the people. "…if the major needs of the community are fuelwood and fodder, the silvicultural prescriptions should be made accordingly" (p.9). In addition the policy of the FD shows a lack of flexibility to react to the diverse requirements of the forest dwellers (POFFENBERGER et al. 1996a) which are often not known. SAXAN (2000) accuse the FD of willingly slowing down the signing of the needed agreements between FD and VFC to weaken the legal status of the VFC. If it comes to the implementation of JFM, the guidance of the villagers in the forest management is often not clearly divided between the FD and the associated NGO and thus, no one takes responsibility for it (SAXAN 2000). SING (2000) even accuses the FD of Tamil Nadu to actually cheat the rural paupers by giving them only a fraction of the income derived out of forest.

The reasons for the slow outcome of JFM success often lies within the different roles the participating groups play. The FD owns the forestland and the local communities are at best participating in management and use, but in an inferior role (POFFENBERGER & SINGH 1996). In most of the cases the FD does not depend on the villagers but vice versa. For a willing and motivated forest officer it is also often hard to build up a trusting and durable connection with the VFC due to a high frequency of staff transfer within the forest administration.[9].
The GOVERNMENT OF INDIA (1999) considers that a lack of experience due to the young history of JFM in India is the reason for the slow development. But this only applies to the establishment of forest protection and management with local communities on the administrative level. Experience in the protection and management of forest through local people exists and can be used as a source of knowledge (POFFENBERGER et al. 1996a).

To continue listing the problems remains unproductive unless an effort is made to focus on them in the specific situation and action is taken to solve them. POFFENBERGER (1996) stresses different points needed to reach the aim of an effective participation of local communities by including them under the official program as well as them carrying out protection on their own initiative. This would include among other things the registration and mapping of the protecting communities, the improvement of flow of information between the participating groups, integration of the VFC in the preparation of the micro-plan and allied research to discover the patterns of forest utilisation.

[9] According to the list of District Forest Officers (DFO) at the Dindigul Forest Department the department was lead by 55 DFOs from 1960-2001 (until 1985 under FD Madurai)

Success will only be possible, if a special interest exists among the members of the FD involved or the local users (AGARWAL & SAIGAL 1996). It is important latter to feel the benefit resulting from the management. “Ultimately it is more the attractiveness than the consciousness of the villagers that will decide upon success or failure of JFM” (SÜSS & SEELAND 1996). This supposes the building up of trust among the involved parties, especially that the FD gives up their controlling and ruling role to make the people feel that they are equal partners. SEELAND (1999) goes even further saying that JFM will not succeed if the ownership of the forest is not transferred from the FD to the users.
However, the foundation of an improvement of the forest situation in India is given and the aim of a sustaining utilisation can be reached if all participants are willing to do so.

2.4 Forestry in Tamil Nadu

The deforestation that happened before the government created reserves had a tremendous effect on the forests of the Madras Presidency, of which Tamil Nadu was a part under the British government. According to FRANCIS (1906) anybody was allowed to harvest timber in the forest up to 1852 and thus the valuable trees were rapidly removed in considerable quantities and the forests were turned into shrub land and “thousands of acres of excellent jungle had thus been ruined” (p.133). As late as 1882 a Forest Act was set up and a forest administration was established (STEBBING 1922). The forests were classified in the three groups of government owned forests (see table 2.1). The area under Reserved Forest increased from 1.3 million ha in 1884 to 12.2 million ha in 1923 (FOREST DEPARTMENT MADRAS PRESIDENCY 1883-1913/1922-23) by 1890 most of the state owned forests had been classified as Reserved Forest.

Today Tamil Nadu has almost no Unclassified Forest (3%) but 86% Reserved Forest and 11% Protected Forest. It has a recorded forest cover of 16% but the actual forest cover amounts only to 13% (17078 km^2) of which slightly more than 50% are dense according to the definition in table 2.2.

According to the rough calculation from the FOREST SURVEY OF INDIA (1995), Tamil Nadu has a total growing stock of 69,287 m^3 giving 40 m^3 per ha. The dense forest contains 57 m^3/ha^{-1} and the open forest 24 m^3/ha^{-1}. The state has an total annual consumption of 7 million tons fuelwood in rural areas (RAI & CHAKRABARTI 1996) of which approximately 50% come from the forest. A rough calculation on the basis of the actual area under forest in Tamil Nadu lead to an utilised amount of 2 tons per ha of forestland. If the average annual growth of 0.7 m^3/ha^{-1} for the whole of India (LAL 1989 and SINGH 1992) is applied to the forest of Tamil Nadu and the ton is taken equal to the cubic meter, the overuse will lead to deforestation by the end of the next three decades. Just like the data for all of India this data is an estimate and the deforestation rate can be assumed to be lower. But the situation calls for a change.

In Tamil Nadu, where the forest act from 1882 with some modifications is still in force, the development towards an integration of the rural population in forest management started in 1961 on a small scale with “Farm Forestry” focussing on the afforestation of community lands (SREEDHARAN & SARCAR 1998). It continued 1981 with the first phase of a Social

Forestry program under financial assistance of the Swedish International Development Authority (SIDA). A rapid afforestation of areas outside the Reserved Forest with the main aim of fuelwood production took place and the first VFCs where formed. But the concept did not function effectively because of the same reasons which apply to the whole of India, combined with a lack of statutory authority of the VFCs (SREEDHARAN & SARCAR 1998). In the second phase from 1986 to 1995 there was an attempt to embrace these problems with the implementation of the Interface Forestry Program which shifted the focus from purely fuelwood plantation to multipurpose uses and involved degraded Reserved Forests (SREEDHARAN & SARCAR 1998, THINAGARAN et. al 1999). JFM was implemented in 1997 with the issue of the respective guidelines (G.O. Ms. No. 342). According to the FOREST SURVEY OF INDIA (1999), at this point of time already 599 VFC were found managing 224380 ha of forestland. Therefore Tamil Nadu ranged in sixth place, according to the area under JFM, among the 22 Indian states that have issued resolutions in JFM.

Along with the implementation of JFM, the next afforestation wave, now called Tamil Nadu Afforestation Project (TAP) with financial assistance through Japan, was started with an operation period from 1997-98 to 2001-2002 (THINAGARAN et. al 1999). The objective of this program "to launch a massive tree planting programme…to bring about balance ecological upgradation and to meet…the requirements of the local people…" (THINAGARAN et. al 1999 p. 17) is similar to the programs of the last decades and indicates a small progress in reaching this aim. A difference is, that it contains two aims: One is the development of the degraded forest and the other one is the reduction of the dependency of local people on the forest. Tree planting and maintenance of the plantation during the project period serve the first. For the second, credits are given to the people of the village to enable them to start small income generating activities (VENKADESH, DFO Dindigul, Interview on 20.02.01). The protection of the forest is in the hands of the VFC which can fine people for using the forest illegally. The Forest Department does not gain any benefit out of the forest under JFM any more except for regeneration of the vegetation under the supply of the demanded forest products through the local people (REDDY, DFO Koadiakanal, Interview on 14.2.01).

Information about the success of this concept for Tamil Nadu could not be found, but chapter 3.7 will describe the situation for the study area.

3 Study area

3.1 Selection of the study area

Through previous fieldwork the author had the opportunity to become familiar with the situation of forest use and degradation in Tamil Nadu. The wish to study the actual situation of the forest utilisation and its socio-economic background in the plains and the contact to the Palni Hills Conservation Council (PHCC), a local NGO, made Tamil Nadu the place of research.

The study area was chosen under the following criteria: forest type, stage of degradation, noticeable interference of the local population, accessibility and the presence of the PHCC and its infrastructure. Two points were substantial for the selection: the area should contain a forest of the typical habit found in the plains of Tamil Nadu and the forest users within the area should be clearly associated with the forest under survey. The small hillocks in the plains fulfil this requirement better than any site in the mountains.

I chose the Kadavakurichi Reserved Forest and its surrounding villages, situated in front of the foothills of the Palni Hills and close to the city of Batlagundu. The PHCC was active in the villages around this forest from 1991 to 2001. The organisation possessed information and connections in and around the study area, which was needed to carry out the planned study.

Ideally the forest should contain almost untouched, well-established forested sites as well as degraded stages. But less disturbed or even undisturbed forests are very hard to find in the plains of Tamil Nadu. They are limited to very small patches hidden in areas, which are very difficult to reach. The only one known to the author of a suitable size is the Alagar Kovil Reserved Forest near Madurai. The great distance between the two sites makes a comparison questionable and the limited manpower and financial resources restricted the study to a single area.

3.2 Location

The study area lies between 77°46’ and 77°51’ eastern longitude and 10°05’ and 10°10’ northern latitude in the Dindigul district of the southern Indian State Tamil Nadu. Tamil Nadu is located in the south-east of the Indian Peninsula and has an area of 130,058 km^2 (CENSUS OF INDIA 1991). It borders on the states Karnataka and Andra Pradesh in the North and on the Bay of Bengal and the Indian Ocean in the East and South respectively.

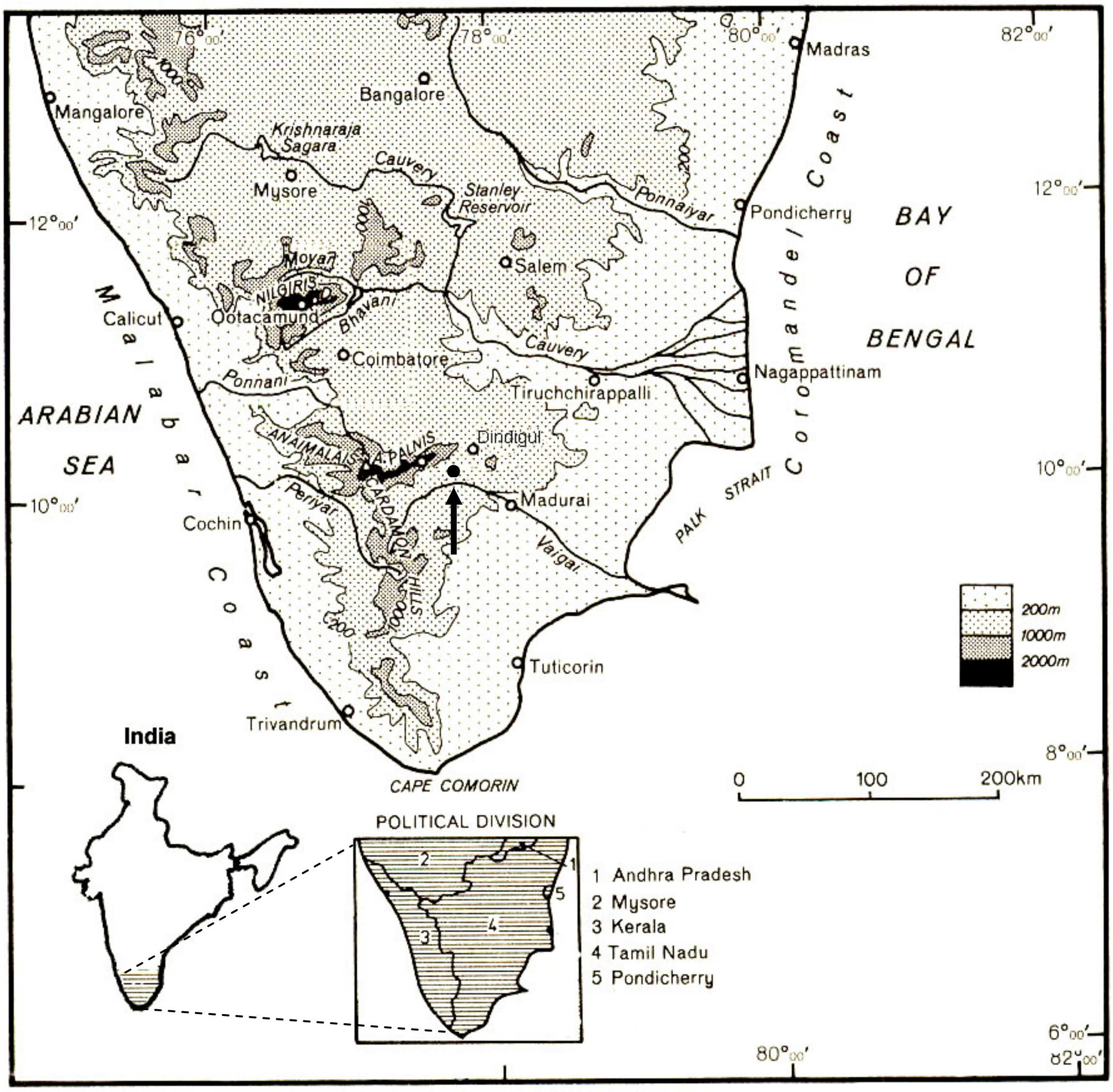


Fig. 3.1: Map of South India (modified from LENGERKE (1977), the arrow points out the Study area)

In the West the state shares the Western Ghats with the neighbouring state of Kerala. They are significant for the climate of Tamil Nadu and dominate the western coast of the Indian peninsula for almost 1600 km. They reach 2695 m above Mean See Level (MSL) at their highest point in Tamil Nadu (PASCAL 1988).

The hill ranges, which are found in the central part of the state are lower in altitude and are considered to be a part of the Eastern Ghats (SUBRAMANIAN & SELVAN 2001). Apart from these hill ranges, a number of isolated peaks rise in the central part of the state (SUBRAMANIAN & SELVAN 2001).

The Kadavakurichi Hillock is one of these small hills. It has an area of almost 10 km^2 and is located south of the Palni Hills, an eastern offshoot of the Western Ghats, between the two cities Batlagundu and Nilakkottai and in the North of the Vaigai River (figure 3.1 and 3.3).

Fig. 3.2: The Kadavakurichi hillock from North West direction

The elevation of the Kadavakurichi hillock ranges from 240 m at the lowest point up to 708 m at the highest peak. The area defined as Reserved Forest (RF) covers 969 ha[1]. The area directly adjacent to the RF, defined by the PHCC as a project area, covers approximately 45 km^2, including the RF (PHCC 1991). In the North, it borders on the road from Batlagundu to Nilakkottai, in the West on the Marudanadhi River, in the South on the Vaigai River up to Bodiagoundanpatty and from there on the road from Bodiagoundanpatty to Kundalappatty. The eastern border is the road from to Kundalappatty to Nilakkottai.

[1] Measurement by the author

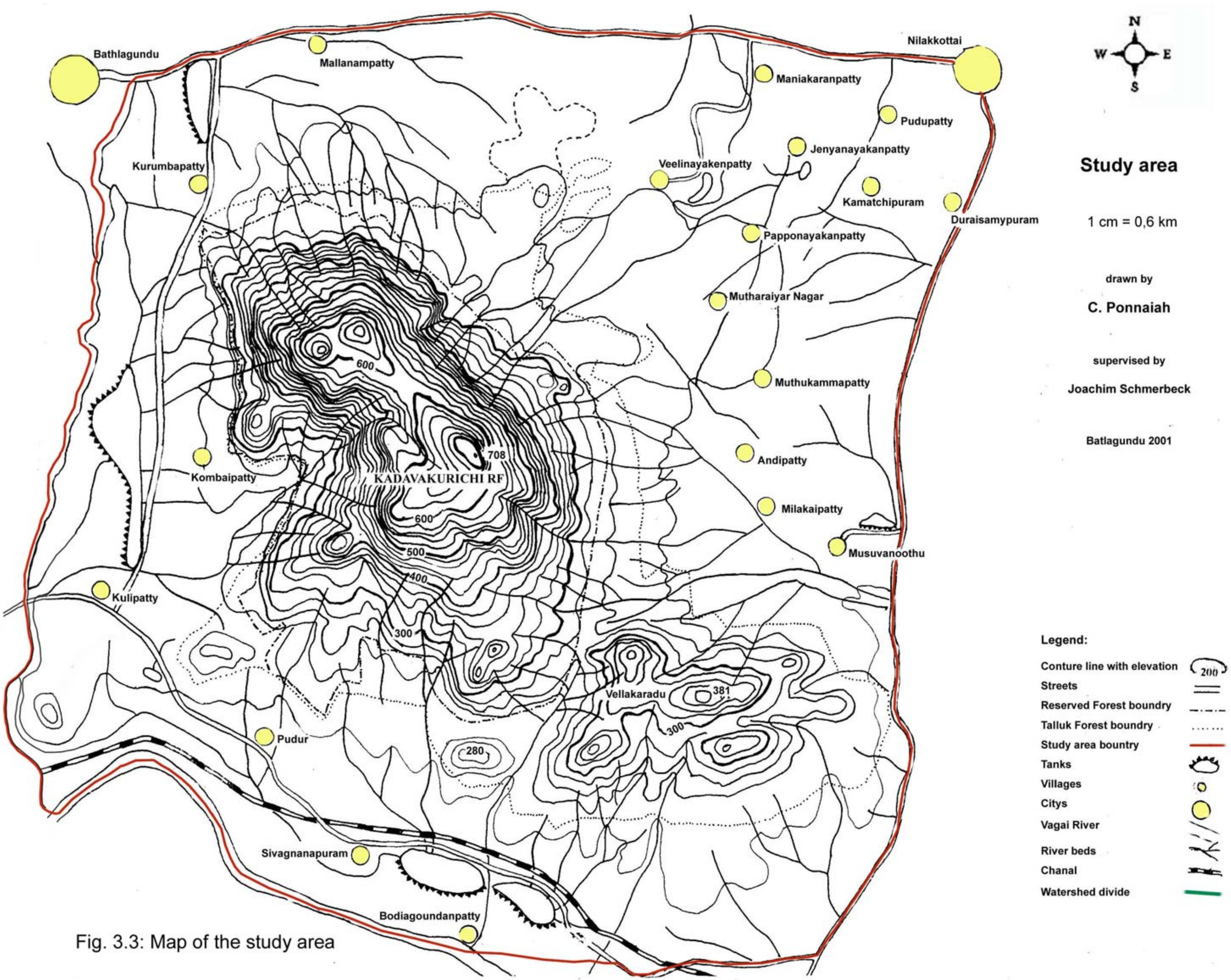


Fig. 3.3: Map of the study area

3.3 Environmental conditions

3.3.1 Climate

According to the Soil Map of Tamil Nadu (1996) the study area is located in the Agro ecological Sub Region "Tamil Nadu uplands" with a hot, semi arid climate and 90-150 days annual growing period.

Rainfall

The mean annual precipitation in Nilakkottai from 1901 to 1996 is 758 mm. The amount of rainfall per annum fluctuates strongly between the different years. The maximum recorded is 1203 and the minimum 8 mm with a standard deviation of 218.05[1].

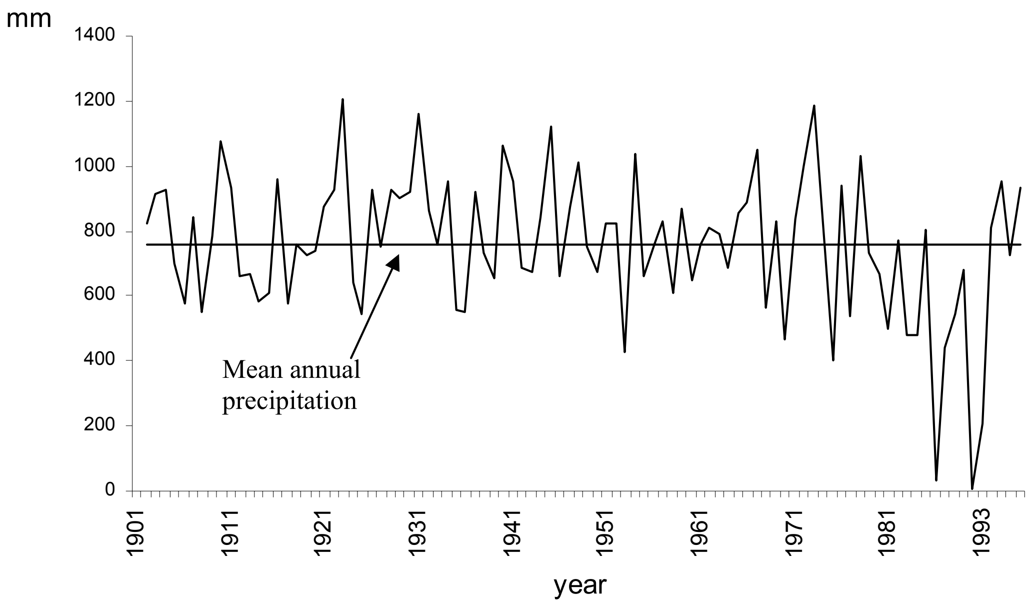


Fig. 3.4: Annual average rainfall at Nilakkottai from 1901 to 1996

In the South of India, two major rainy seasons can be observed: The South West (SW)- and the North East (NE)-Monsoons. The SW-Monsoon starts at the end of May/beginning of June at the southern tip of India (PASCAL 1988) and leads to heavy rain on the western slope of the Western Ghats while the eastern side and the plains of Tamil Nadu remain almost untouched (BLASCO 1971, SANKARARAJ et al 1985). The precipitation in the study area during the months of June till August, which can be taken as the time period of the SW-Monsoon passing Tamil Nadu, is almost 18% of the mean annual precipitation. The SW Monsoon withdraws to North India in September (PASCAL 1988) and passes through Tamil Nadu again between September and December as the NE Monsoon, causing the main rainy season with

[1] Data from Nilakkottai 1901 to 1996, provided by the India Meteorological Department Pune, year 1992 missed

almost 53% of the average annual rainfall in the study area between September and November (figure 3.5). It includes the rain from cyclonic storms, which are formed over the Bay of Bengal in this time and lead to heavy rainfall where they pass (DILLEN forthcomming). A second peak of rainfall exists for the summer months of April and May. It is caused by thermal convectional rainfall (PASCAL 1988, DILLEN forthcoming) and adds up in Nilakkottai to almost 19% of the annual precipitation. These rains often fail in the study area (PHCC 1991). Six months receive less than 60 mm of rainfall.

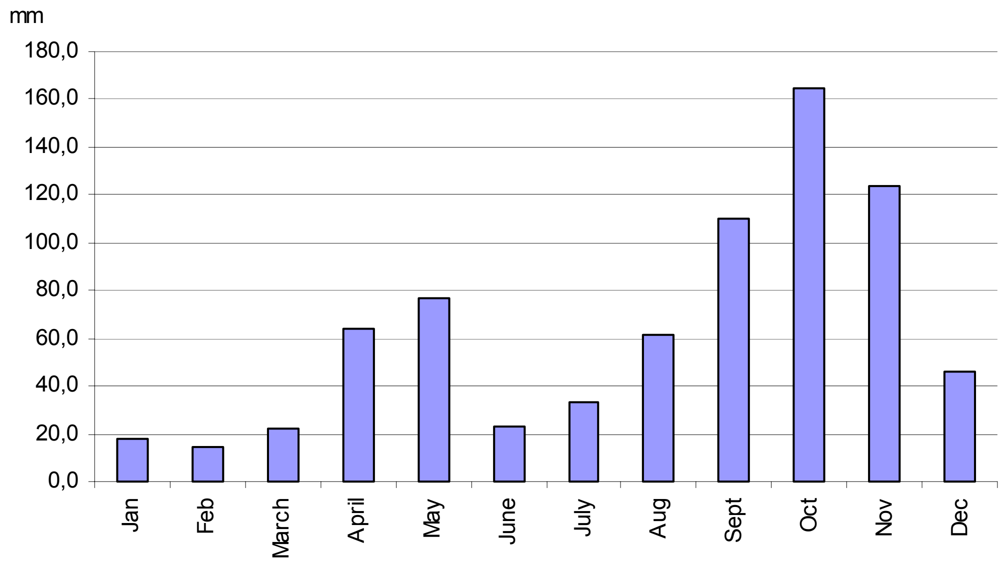


Fig. 3.5: Monthly average rainfall in Nilakkottai from 1901 to 1996

Heavy rainfall of more than 100 mm in 24 hours occur mainly between October and December but also in March and July there can heavy rains.

Temperature:

Data of the temperature of Nilakkottai were not available. The closest meteorological station for which data can be provided through the Meteorological Department Pune is Madurai, 50 km south of the study area at an elevation of 100 MSL.

In the annual average the maximum temperature ranges from 29 to 35°C and the minimum from 20 to 24°C. The absolute maximum between 1901 and 1996 was 42 °C and the absolute Minimum 15°C.

Figure 3.6 shows, that April and May are the hottest months while December and January are the coldest.

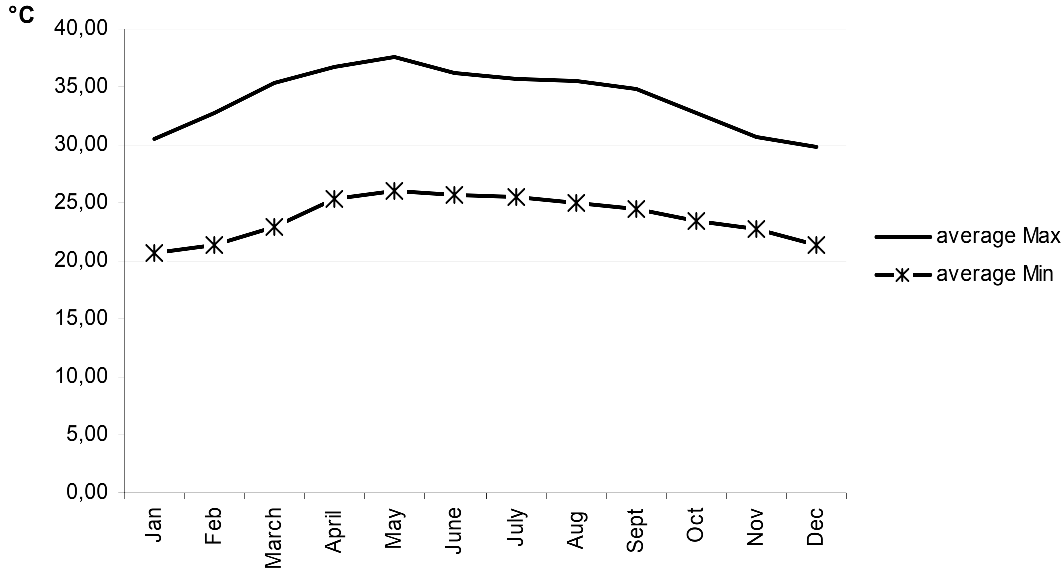


Fig. 3.6: Monthly average temperature at Madurai

3.3.2 Geology and Soil

Geology

The dominant geological formations in the peninsula of India are crystalline rocks. They cover 80% of Tamil Nadu (SUBRAMANIAN & SELVAN 2001) and are "rocks of the Charnockite Group, the Khondalite Group, and gneisses and schists, traversed by ultramafic, basic, granite and syenite intrusives" (GEOLOGICAL SURVEY OF INDIA 1974, p. 9).
A detailed geological map of the study area does not exist. SANKARARAJ et al. (1985), who concentrated on the description of agricultural soils, show on their "Geological Map of Anna District" mainly unclassified gneisses for the study area. Our own observations have shown that the rock of the Kadavakurichi Hillock is Charnockite as it occurs also in the Palni Hills. The other parts of the study area consist of charnockite and broad bands of Quartz. The surface of the soil is mainly rubble with large parts of quartzite. Quartzite can be a member of the Charnockite group (SUBRAMANIAN & SELVAN 2001) which leads to the assumption, that the whole study area could be classified as such. Charnockite, named after Charnock, founder of Calcutta (PASCAL 1988, FOUCAULT A. & RAOULT J.F. 1995.), forms a unique high standing relief in South India and Sri Lanka (GUNNELL & LOUCHET 1999) and major parts of the southern Western Ghats. Prominent hill ranges in Tamil Nadu are formed out of this rock (GEOLOGY SURVEY OF INDIA 1974, PASCAL 1988, SUBRAMANIAN & SELVAN 2001).
The classification of charnockite is not clear. Because of the assumed genesis it is considered as a metamorphic rock (a variety of granulite) but because of its texture as a magmatic rock (FOUCAULT & RAOULT 1995, SCHUMANN 1997). It can be of dark (greenish) or light (whitish to yellowish) colour and contains as characteristic minerals quartzite, feldspath and hyperstene (PASCAL 1988, FOUCAULT & RAOULT 1995, SCHUMANN 1997). It contains also plagioclases, biotite amphiboles and garnet. "Depending on the proportion of hyperstene and other ferro-magnesian minerals the rocks … are varying from a basic to an acidic pole" (PASCAL 1988 p. 7).

Soil

The charnockite of the hillock weathers to a silty or rubble sand, which gives a shallow, very stony skeletal soil with hardly any top soil.

Fig 3.7: Typical soil profile of the Kadavakurichi RF

According to the Soil Map of Tamil Nadu (SEHGALS 1996), the soils of the research area are typical Ustropepts. They cover 12% of Tamil Nadu. Ustropepts is a large group of the Tropepts, a suborder of the Inceptisols (BUOL et al. 1995)[2]. Ustropepts have a base saturation higher than 50% from 25 cm to 1 m of depth (BUOL et al. 1995, BSWM 2001) and have an ustic moisture regime (BUOL et al. 1995). That means, their moisture is limited, "but present at a time when conditions are suitable for plant growth" (USDA 1998)[3].
The soils of the remaining study area are of similar texture as those of the hillock. To the greatest part, they belong to the Irugur series. This soil type is dominant in the plains of the district with 50% of the surface. It is non-calcareous, reddish brown to yellowish red, shallow to deep with or without a diagnostic horizon. It is well drained on the surface and rapidly permeable (SANKARARAJ et al.1985). On irrigated agricultural fields, stones are removed and additional clay makes the soil able to store more water. In the South, along the Vaigai River, an alluvial more fertile stripe exists.

[2] This classification is not the actual one but used here due to the application on the soil map of Tamil Nadu (for the actual classification see USDA 1998)
[3] Such a soil is moist in some parts for more than 180 cumulative or more than 90 consecutive days per year (USDA 1998).

3.3.3 Vegetation

The climatic conditions of the Indian peninsula vary strongly and thus a variety of biomes can be found. They vary from desert and grassland to savannas and forest to mangroves. Due to the extremes in rainfall and temperature different types of forest have developed. They contain a high number of species not comparable with what is found in Europe. BRANDIS (1906) gave a good example as he compared a French Forest Flora containing 397 species with his incomplete "Indian Trees" dealing with 4400 tree species. Taking also the variety of utilisation patterns and human impact in accoun, one can consider that a classification of this forest is not easy to undertake. Several authors set up different classification systems for practical or scientific purposes.

CHAMPION & SETH (1968)[4], the most cited reference, sort the forest into different forest types defined as "a unit of vegetation which possesses (broad) characteristics in physiognomy and structure sufficiently pronounced to permit of its differentiation from other such units. This is irrespective of physiographic, edaphic or biotic factors" (p. 1). The main characterising factor is the main tree layer or the most emergent vegetation. Shrubs and ground flora play a subordinate role in the classification of the types.

MEHER-HOMJI (1967/1977) allocated the vegetation of India to series, which are formed out of the same forest type defined as the "different physiognomic stages of vegetation encountered in an ecological region". The name for a series is a combination of two to four species that are taken from the plesioclimax, which is defined as "the final, maximum stage of the series. Theoretically, it is defined as the stage a given piece of vegetation would reach in a sufficiently long period of time, without human interference. In practice it is recognised as the most developed formation met within an ecological region." (MEHER-HOMJI 1967 p. 32).

Main forest types in the plains of Tamil Nadu

The Western Ghats act as a barrier for the South-West Monsoon and the slopes exposed to sea breeze from the West collect more rainfall than the areas to the east. This explains why the western slopes of the Western Ghats are covered by rainforests (PASCAL 1988). On the east of the Western Ghats the vegetation changes more and more into dry and thorny forest types (CHAMPION & SETH 1968).

According to the classification of CHAMPION & SETH (1968) three main forest types occur in the plains of Tamil Nadu[5]:

Southern Tropical Dry Deciduous Forest

Southern Tropical Thorn Forest

Tropical Dry Evergreen Forest

According to the FOREST SURVEY OF INDIA (1987 in BAJA 1992), 55% of the state's forest area is covered with Southern Tropical Dry Deciduous Forest while the Thorn Forest takes 10%. The Dry Evergreen Forest is limited to a small strip on the east cost of Tamil Nadu and covers only 5% of the forest area.

[4] On the base of CHAMPION'S classification 1936

[5] a detailed classification of these forest types is given in appendix 3.2

The following table shows the different main forest types of Tamil Nadu and their characteristics described by CHAMPION & SETH (1968) and by MEHER-HOMJI (1967/1977).

Autor	CHAMPION & SETH (1968)			MEHER-HOMJI (1967)	MEHER-HOMJI (1977)
Forest type	Southern Tropical Dry Deciduous Forest	Southern Tropical Thorn Forest	Tropical Dry Evergreen Forest	*Albizia amara-Acacia* series	*Hardwickia binata* sub type of Dry Deciduous Miscellaneous Forest
Formation	Closed, uneven not very dense upper canopy 13-20 meter in height	Open low forest in which thorny usually hard wooded species predominate	9-12 m high forest with a complete canopy, trees with short boles and spreading crowns	Scrub woodland with an open canopy of less than 10 m height and a thick undergrowth	Not given
Main tree species	Teak typ: *Tectona grandis* *Anogeissus latifolia*, *Terminalia spec*. Non-teak type: *Anogeissus latifolia*, *Terminalia spp*. *Dicypyros spp*., *Bswellia spp*., *Sterculia spp*	*Acacia catechu*, *Acacia spec*., thorny Mimosae, *Ziziphus spp*., *Anogeissus latifolia*, *Soymida spec*., fleshy *Euphorbias*	*Manilkara hexandra*, *Mimusops elengi*, *Diospyros ebenum*, *Strychnos nux-vomica*, *Eugenia spp*. *Drypetes sepiaria*	Upper canopy: *Albizia amara*, *Chloroxylon swietenia*, *Acadia leucophloea*, *A. planifrons* and others Under storey: *Dichrostachys cinerea*, *Pterolobium indicum*, *Randia dumetorum* and others	Upper canopy: *Hardwickia binata*, *Aegle marmelos*, *Anogeissus latifolia*, *Chloroxylon swietenia* Under storey *Carissa spinarum*, *Ziziphus mauritiana*, *Pterocarpus santalinus*, *Euphorbia antiquorum*
Climate					
Annual precipitation mm	In general 850-1300 Examples between 715-1700 (Champion 1936 gives 500 as minimum)	Examples between 460-943 (Champion 1936 gives 306 as minimum)	Examples between 872-1268	600-1000	500-1200
Mean Temp. min	18-23	23-25	19-25	no data	no data
Mean Temp. max	29-35	32-35	30-33	no data	no data
Number of dry month	5-8 (< 60 mm)	4-9 (< 50mm)	4-6 (< 50mm)	6-8 (no definition)	6-8 (no definition)
Remarks	Can merge into Thorn Forest below 750 mm				

Tab. 3.1: Main forest types in the plains of Tamil Nadu.

According to the map of forest types given by CHAMPION & SETH (1968) the study area belongs to the Southern Tropical Dry Deciduous Forests. The annual precipitation is below the range CHAMPION & SETH (1968) give as a general range for this forest type. But at the sites they describe it for, it occurs from 715 mm onwards and according to CHAMPION (1936) the annual rainfall can even drop down to 500 mm. Under 750 mm it can merge into Thorn Forest (CHAMPION & SETH 1968). This forest type occurs throughout the dry peninsular tract to the lee of the Western Ghats and is an important forest type in Tamil Nadu (CHAMPION & SETH 1968).

A similar range, temperature and number of dry months of these two types suggests other determining factors.

The study area is, according to this classification, within the range of both forest types. With an average annual rainfall of almost 760 mm with six months receiving less than 60 mm precipitation it is placed in the climatic condition of the Southern Tropical Dry Deciduous Forest, while the actual vegetation shows the characteristics of a Thorn Forest (see also chapter 5.2 and 6.2.2).

MEHER-HOMJI (1967) groups the largest part of the peninsular of Tamil Nadu, including the study area in the *Albizia amara-Acacia* series. In his mapping and description of the Dry Deciduous Forest (MEHER-HOMJI 1977) he gives almost no type or sub type of this formation for Tamil Nadu. Only the eastern parts of the Western Ghats are classified as Dry Deciduous Teak Type and the north - east corner of the state as the *Hardwickia binata* sub type of the Dry Deciduous Miscellaneous Type. This would mean, that in almost the entire Tamil Nadu no Dry Deciduous Forest exists. But according to the climatic conditions of the Dry Deciduous forest given by MEHER-HOMJI 1977 (700-2000 mm, 8 month dry season) the study area suits this forest type.

The actual forest

The actual forest of the plains around the Palni Hills under 900 m elevation consists according to BELLAN & BLASCO (1980) of tree savanna, more or less open thorn thicket and pseudo-steppic vegetation with barren rocks. These authors map dry deciduous forest only on some places on the northern slopes of the Palni Hills (see fig 3.8).

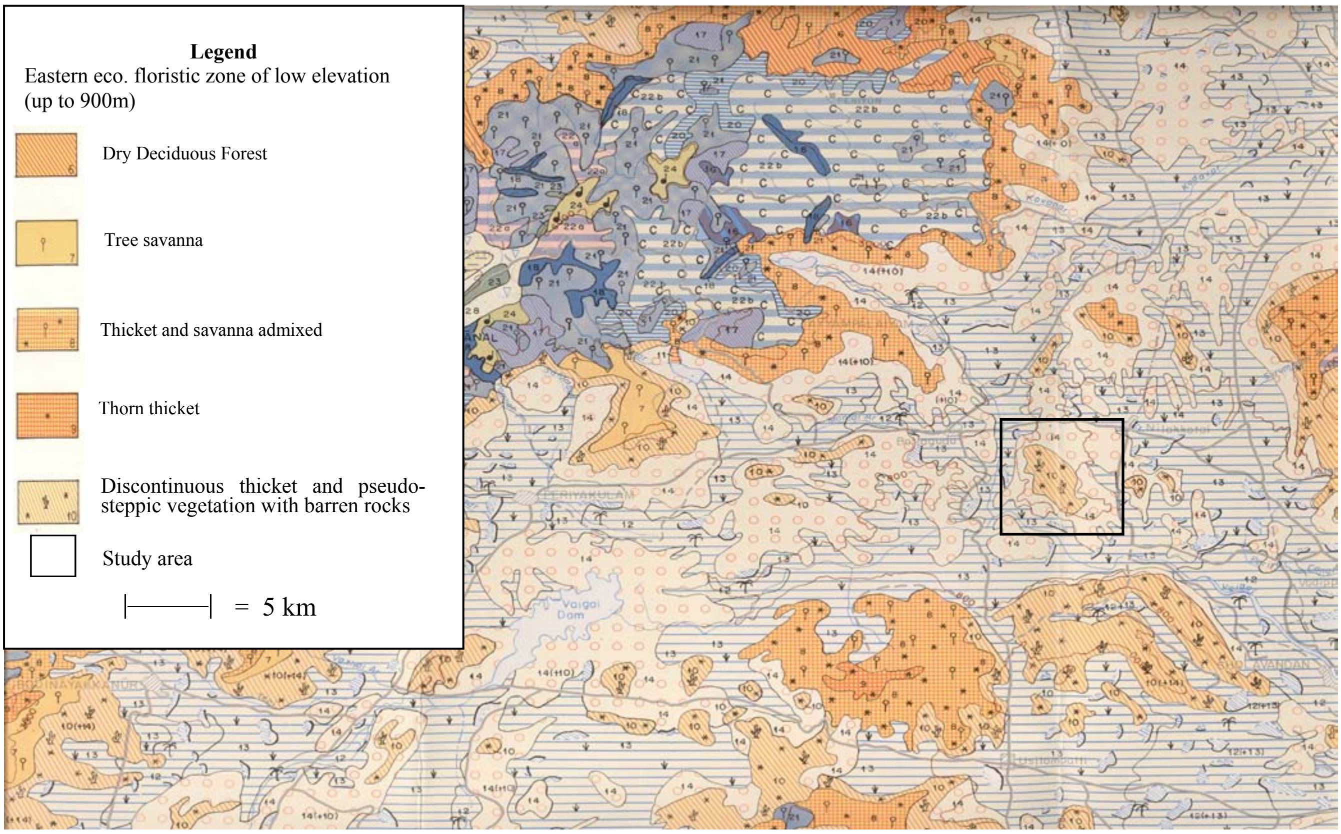


Fig. 3.8: Extraction from the vegetation map of the Palni Hills (BELLAN & BLASCO 1980). The legend focuses on the elevation relevant for the study area.

The Kadavakurichi is mapped as “Discontinuous thicket and pseudo-steppic vegetation with barren rocks”. This is the poorest of the mapped vegetation types, covering a large part of the surrounding areas.

The Kadavakurichi RF shows alternating vegetation of thick thorny scrub, more open areas with discontinuous cover of shrubs and trees and open grasslands. All common trees and shrub species are armed which makes it almost impossible to pass through dense groups of woody plants. (A detailed description and classification of the Kadavakurichi RF is given in chapter 5.2 and 6.2.2).

Various authors explain such a forest structure with the heavy human influence due to fire, wood cutting and grazing (LEGRIS 1963, CHAMPION & SETH 1968, BLASCO 1983, PASCAL 1986/1992, LEGRIS & BLASCO 1974). BLASCO (1983) describes the transformation from deciduous forest of dry climatic condition (< 1000 mm precipitation) as found in the peninsular of India, through a thorny thicket with *Euphorbia* into a low scattered shrub, as a result of human impact. Thus the succession can move in both directions between the Southern Tropical Dry Deciduous Forest and thorny scrubs (CHAMPION & SETH 1968). This dynamic relationship between different successional stages of deciduous forest is shown exemplary by PASCAL & RAMESH (1992) for the area between Salem and Bangalore with elevations between 300 and 1300 MSL[6] (figure 3.9)

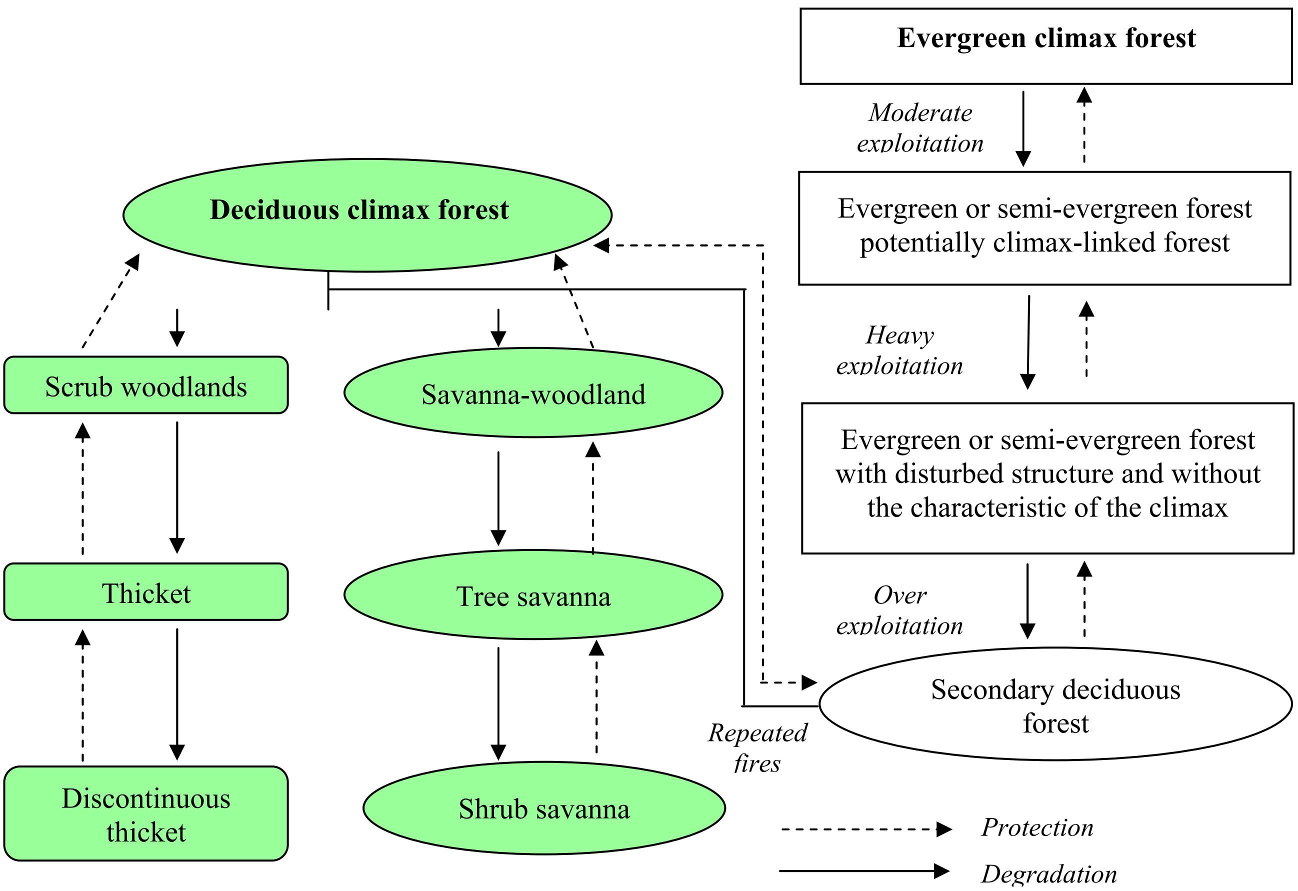


Fig. 3.9: Stages of succession derived from climax forests (PASCAL & RAMESH 1992)

[6] The sheet containing the Palni Hills and the study area was not available at the time of setting up this thesis

The climax

The classifications that exist for the forest of Tamil Nadu do not give any information about the forest type that forms the final stage of a development without human input. This forest formation is usually called "climax".
The authors who classified the Indian forest mainly refer here to the definition of the climatic climax given by CLEMENT & ALLRED (1949, in MEHER-HOMJI 1963 and in CHAMPION & SETH 1968): "The final stage of succession, which continues to occupy an area as long as the climate remains unchanged". This definition suggests a balance between climate and vegetation over a large area after a given period of development and can be described as mono-climax (MEHER-HOMJI 1963). Other authors link the climax to local features (polyclimax, GAUSSEN 1933 in MEHER-HOMJI 1963) or think even of a mosaic of different development stages in one section of the landscape like REMMERT (1991). A vegetation which is under human influence in a way that a stable balance with the vegetation is established may also be titled as climax, like GOLDAMMER (1993) does this for anthropological fire eco-systems.
In this study only a broad picture of the forest that would emerge over time if human influence would be absent shall be described and discussed and thus the definition of CLEMENT & ALLRED will be used here.

The question of the climax of the study area can not be answered satisfactorily. The heavy influence of man during the last centuries has modified the vegetation in a way, that the climax can rarely, if at all, be observed and that it is "difficult to propose a theoretical reconstruction of what could have been the climax" (PASCAL & RAMESH 1992, p. 6).
Figure 3.8 shows that the vegetation types found in the plains and lower elevations around the Palni Hills at present are similar to vegetation types that are a result of overusing and exploitation. In the case of such an influence they are a degraded form of the Dry Deciduous Forest and could even be the product of a degraded semi-evergreen or evergreen climax forest. BARRINTON (1931) and STOTT (1986, both in GOLDAMMER 1993) support this view with the suggestion that the savanna-forests of Southeast Asia are partially potential evergreen or semi-evergreen forests.

A detailed research of less disturbed areas and the dynamics of its vegetation would be needed to come close to a forest type that can be suggested to be the climax of the Kadavakurichi. Such areas are absent. Less disturbed forest formations are mainly located where humans can approach only under great effort and which are not threatened by fire, or around temples and holy places.[7] Such places can be indicators for the species composition of previous stages of degradation and allow speculation about the climax vegetation. Species found on such undisturbed spots like *Lepisanthes tetraphylla*, *Diospyros ebenum* and *Drypetes sepiaria* (see chapter 5.2) are, according to CAMPION & SETH's classification (1968) part of the floristic composition of the Tropical Dry Evergreen Forest. They are scattered in surrounding areas of the Kadavakurichi like Senkattanpatti RF (neighbouring Hillock), lower elevations of the Sirumalai RF, the foothills of the Palni Hills near Majalar Damm (personal observation, JEAN POYET 2000, verbal information) and on a few other places on the Kadavakurichi RF under less human pressure. The Tropical Dry Evergreen Forest is, regarding CHAMPION & SETH

[7] For information about Temple Forests see CHANDRAKANTH et al. (1990).

(1968), restricted to the South East of the Indian peninsula. It occurs directly on the coast as well as on other places further inland near Madurai and Tiruchirappalli (Trichy) (50 km south and 100 km north of the study area respectively). Considering these two places, a geographical connection of the study area to one of the Dry Evergreen Forests exists. According to the dry period (number of dry month) the study area fits this forest type and the amount of rainfall. It does not vary extremely from the lower end of the range of precipitation given for the Tropical Dry Evergreen Forest (table 3.1).
To conclude that these indicators suggest that the potential climax of the study area is a Dry Evergreen Forest Type would be too speculative. On the other hand, this observation and the above given dynamics between different forest types do not allow the repudiation of this option (see chapter 6.2).

3.4 The socio-economic situation

3.4.1 Institutions and infrastructure

The Dindigul Anna District is one out of the 30 Districts of Tamil Nadu (CENSUS OF INDIA 2001). It was formed in 1985 through separation from the Madurai district (CENSUS OF INDIA 1991) and consists of six administrative subunits (taluks) which are divided into Community Development Blocks (CD-Block). The study area belongs to the Nilakkottai taluk and is part of the two CD Blocks of the taluk. The western and northern part belongs to the CD Block Batlagundu and the western and southern part to the CD Block Nilakkottai. The next administrative unit is the Panchayat which comprises a small number of villages. These villages elect a president who is the contact person to upper administrative levels.
The study area includes 19 villages belonging to 5 different panchayats.

School education up to primary level in the study area is provided in the villages. Further education can be received in Batlagundu and Nilakkottai. Both towns have a higher secondary school. The next universities are at Madurai and Tiruchirappalli (Trichy).
Governmental and private hospitals are also represented in both towns. On the village level, small health care centres of the government exist.
The forest department in Dindigul is in charge of the Kadavakurichi RF. The forester and forest ranger are placed in Batlagundu. Three forest watchers are in charge of the forest in the study area (Kombaipatty, Pudur and Veelinayakenpatty)
The road between Batlagundu and Nilakkottai connects the area with Kodaikanal and Periyakulam to the West and with Madurai to the East. Dindigul, in the North of the study area, can be reached in both ways. A tarred road surrounds the study area and connects the villages.
The next railway station is Kodaikanal road (Ammayanayakkanur), 18 km to the East on the road from Madurai to Dindigul.

3.4.2 Population and castes

Population

The Dindigul Anna District has a total population of 1,9 million people, which results in a density of 317 people/km². This is below the average for Tamil Nadu State (478/km²) (Census of India 2001). Within the district, the density varies strongly between the hill areas and the plains. The census 1991 shows for the Kodaikanal Block (Kodaikanal taluk) a population density of 92/km² and for the Dindigul Block (Dindigul taluk) 1676 people/km². The Nilakkottai taluk is relatively high populated with 773 people /km².
The distribution of the population to rural and urban areas[8], shows a clear trend to a growth in favour of the towns. In 1991 66% of the population of Tamil Nadu lived in rural areas and in 2001 this was reduced to 59%. In the Dindigul district the ratio of rural population in 1991 of around 78% changed to 65% in 2001. The census 1991 gave the Nilakkottai taluk a rate of 85% rural population and therefore the second last place in the urbanisation rate within the district.
The population growth of the Nilakkottai taluk was with almost 14% in the years 1981-1991 in second place in the district behind Kodaikanal with 18% and above the district average of 12,5%.
The study area is inhabited by around 13330 people (PHCC 1998) with a population density of 296 people/km². The population density is therefore near the district average.

Castes

Within the study area 20 castes are represented (PHCC census 1996, appendix 3.1), of which the most frequent are the Moopar (23%), Thevar (17%) and the Nayakkar (14%).

It is difficult to find reliable information about these castes, their origin and development. In addition the spelling of their names vary. Therefore only a short description of the three main castes shall be given here.

As observations show, the *Moopar* seem to be the main caste involved in the utilisation of the forest. A caste name Moopar can't be found as such in the available literature. The terms "Muppar" (SING 1998a) and Muppan (THURSTON & RANGACHARI 1975) show the highest similarity.
Muppan" means in Malayalam (language of the neighbouring state Kerala) "old people" or "the older one" (SINGH 1998a, THURSTON & RANGACHARI 1975). A connection of the Muppans with the forest is found in FAWCETT (1912), who describe the customs of a tribe in Wynaad, Malabar (Kerala) that he calls Muppans. This tribe "live by cultivation and collection of jungle products". SINGH (1998a) does not connect the Muppans to the forest. He says, that they had been traditionally involved in carving temple sculptures. According to THURSTON & RANGACHARI (1975) Muppan is the title of many classes. Among them only the "Valaiyans" (or "Valai") show a connection with the forest. The Tamil term "valai" means "net" and it has been given to them, because they used to hunt and fish with nets in the jungle (FRANCIS 1906). THURSTON & RANGACHARI (1975, p.273) quote the Madras Census Report

[8] As per definition given by the census of India 1991

of 1901 where they are described as “a shikari (hunting) caste in Madura and Tanjor”, and the Tanjor Manual (no reference given) say, that the Valiyans are engaged in “agricultural labour and coolie work, … cutting and selling fire-wood. They are a poor and degraded class”. In the Gazetteer of 1914 they are mentioned as one of the main castes in the Madurai district (FRANCIS 1906). That this caste was represented near the study area is note by the same author. He mentions the Valaiyans of Ammayanayakkanur (Railway station Kodaikanal road, 18 km to the East of the study area) as the pujaris[9] of the God of the nearby hill range (Sirumala hills).

Regarding (Singh 1998b) the *Thevar* (or Tevar), have their main domain in South Tamil Nadu. But they are also represented in Kerala, Karnataka and Maharashtra. To the latter they migrated during the last 50 to 60 years in search of jobs, while they moved to Kerala in recent years. Mukkulattor is a synonym for Thevar and means “people of three subcaste”. People of these three sub-castes in Tamil Nadu (Kallar, Maravan and Agamudayar) were considered to be troops, guards and soldiers in earlier times (SINGH 1998b). Their mother tongue is Tamil and nowadays they are farmers, agricultural and industrial labourers.

The PHCC (1991) spell the name of the third most frequent caste as “Naicker” and in their census in 1998 “Nayakar” or “*Nayakkar*”. SINGH (1998b, p. 2621) and THURSTON & RANGACHARI (1975 p. 283) describe a caste called Nayar, a name derived from the Sanskrit “Nayaka”, meaning leader and quote MOORE (1905) who says that the term Naik and Nayakan also derived from the same Sanskrit roots. “In origin the Nayars were probably a race of Dravidian immigrants, who were amongst the first invaders of Malabar and, as conquerors, assumed the position of the governing and land-owning class” (THURSTON & RANGACHARI 1975 p. 284). Malabar lies is Kerala but the community is also represented in Tamil Nadu, where they temporarily ruled some regions (FRANCIS 1906). THURSTON & RANGACHARI (1975) suppose a connection of the Nayars from Malabar to the Vijayanagar kingdom in the North of Madurai (1336-1664, CHOPRA 1979). The Nayars are always described in their origin to be a military body or warriors (STUART 1891 in THURSTON & RANGACHARI 1975a, THURSTON 1909 in SINGH 1998b and THURSTON & RANGACHARI 1975), but today they include traders, artisans, barbers and washermen among others. STUART (1891 in THURSTON & RANGACHARI 1975a) explains this through the migration of people into Kerala who adopted the customs and manners and assumed the caste names of the communities that surrounded them.

In the study area they were important as rulers in Madurai and Dindigul from the middle of the 16th century to 1736 (FRANCIS 1906).

[9] Pujah or Pooja is a Hindu ceremony of worshiping Gods

3.4.3 Housing

Bricks is the costliest material for house construction in the study area. Stones collected from the field mixed with loam or loam only are cheaper. The most costly roofs are flat and made of concrete. A roof truss made out of coconut beams covered with tiles and asbestos plates are less costly. The cheapest way to get a habitable building is a temporary construction out of poles and coconut leaves and grasses, here called “light material”. The coconut leaves are plaited in a special way, so that they become “Leave-tiles” which are called “keeth”. The grasses are collected in the forest (see chapter 5.2.1.2).

Fig. 3.10: Typical houses in the study area: out of bricks and tiles (above), with walls out of clay and a grass roof (middle) and made from coconut tiles and grass

3.4.4 Economy

Tamil Nadu is one of the fastest growing states in India. The GDP (Gross Domestic Product) of Tamil Nadu grew in 1997/98 by about 7.9 % while the GDP of entire India grew only about 7.1 % (Government of Tamil Nadu 2000b). The per capita GDP of Tamil Nadu was 17,247 Rs (ca 369 US$) in 1997/98 with was above the state GDP of14,775 Rs. Almost 50% of the GDP is produced in the service sector, 30 % in the industry and 22% from agriculture and connected activities (calculated by Government of Tamil Nadu 2000b).
Although it is the smallest part in the added value of the state, agriculture plays an important role in the state economy because it employs almost 60% of the main workers[10] (CENSUS OF INDIA 1991).
For the Dindigul district this ratio is even higher than that of Tamil Nadu with 70%. The reason could be that big industry is limited in the district. The industry consists mainly of tanning and lock production. The district has 2106 factories of which 1726 produce on a small scale and 69 tanneries in and around Dindigul (CENSUS OF INDIA 1991).
For the people in the study area the employment possibilities are limited. Most of them are day-labourers (chapter 5.2.1.5). Big industries, which can provide job opportunities, are in Dindigul and Madurai while in Batlagundu and Nilakkottai there are only small-scale industries.

3.4.5 Land use

More than 50% of the land surface of Tamil Nadu is used for cultivation of which 45% is under irrigation. Around 17% is forest, 15% is bare (not cultivated agricultural land), 15% is under non-agricultural use and 4% is barren and not cultivatable (Government of Tamil Nadu 2000a).

Regarding the PHCC (1991), 61 % of the land in the study area, except the Reserved Forest, are under cultivation of which half is irrigated (including rivers, canals and tanks (9%)). The land which is not under cultivation consists of non-cultivatable waste (wasteland) (13%), taluk forest (9%), *Acacia planifrons* plantations (7%) and others[11] (10%). The taluk forest is a forested small hillock in the southeast corner of the study area (local name: Vellakaradu). This forest is under the administration of the Nilakkottai taluk[12] and shall be referred to as “taluk forest” in this study. In addition, a strip of land around the RF is claimed by the taluk (see figure 3.3). Both are only loosely protected. Grazing and woodcutting is going on and in flat areas fields of dry crop agriculture can be seen.
The *Acacia planifrons* plantations are thorny shrubs where *Acacia planifrons* is a major species. Also some of the public land and the uncultivable land are covered with thorn plants and other shrubs. These shrubby patches are used for fuelwood collection and grazing. Around 24% of the land are in public ownership including mainly the taluk forest, *Acacia planifrons* plantations, tanks and others, while the private land includes the cultivated land and the wasteland.

[10] People regularly employed as workers. They amount to 40% and 47 % of the total population in Tamil Nadu and Dindigul District respectively
[11] Miscellaneous public land and area under construction
[12] A taluk is a sub-district.

The changes in the land use since 1991 have not been studied, but it can be estimated on the basis of observations, that the area under irrigation increased slightly but constantly. On the irrigated land mainly annual crops are grown like vegetables and flowers. Around 7% (calculated from PHCC 1991) of the irrigated land are used for coconut and other fruit tree plantations.

3.5 Forestry

According to information of the PHCC and the people form Kombaipatty this village was once the residence of a local king (Zamindar). These kings used to own forestland and it is likely, that the Kadavakurichi was at least partially in the ownership of this family, but exact information was not available. The first official record of the Kadavakurichi was found in the FD Annual Administration Report 1885 of the Madras Presidency as “Jungle Reserve” with a size of 5120 acres (2072 ha). This is more than twice the size of today. There are no records available about the additional area that was covered. Table 3.3 will show that parts of the project area, which could have been former parts of the Reserved Forest and are now under several stages of degradation (wasteland, taluk forest, plantations) cover 30% of the project area outside RF. This is more than 1000 ha and therefore in the range of twice the size of today’s RF. According to the forest history of Madurai District given by Francis (1906) the worst wave of deforestation had already taken place in the beginning of the twentieth century. The Annual Administration Report 1892 gives 3200 acres (1295 ha) for the Kadavakurichi RF. It is not mentioned again in the following volumes. The District and Province Gazetteer of Madurai 1930 list the Kadavakurichi RF with an area of 914 ha. This is even less than today’s area of 970[13] ha. The taluk forest has a size of 320 ha.

The Kadavakurichi is not mentioned in the latest working plan of the Dindigul Division 1984/94 but the Forest department had carried out afforestation work in previous decades. Official records were not available. According to information from the PHCC the plantations of *Acacia planifrons* were undertaken by the FD some time ago to create a thorny belt at the foot of the hillock. Some of these trees have developed to considerable size while others developed into a thick scrub under human pressure. The existence of many tree species with a low number of individuals and small groups of timber trees like *Erythrina suberosa* and *Dalbergia latifolia* indicates other afforestation activities through the FD.

The actual activities were all done in the frame of JFM programs (see next chapter). Several check dams were erected in old riverbeds to slow down the water run-off and soil erosion. In addition 100-500 tree saplings per ha were planted while the density decreased from lower to upper elevations. The tree species were mainly selected according to the dry site conditions and the second priority was a multipurpose use. The planted species where among others *Albizia lebbeck*, *Terminalia arjuna*, *Tamarindus indica*, *Holoptelia integrifolia*, *Pterocarpus marsupium*, *Wrightia tinctoria*, *Dalbergia sissoo* and *Syzygium cumini* (VIJAYAKUMAR, forester Batlagundu, Interview on 14.12.00).

The trees were planted in the open patches in big holes. Due to the fires, exposition to direct sun, grazing, damage through passer-by and insufficient rain the survival rate was insignificant (own observation).

[13] Measurement by the author

3.6 Joint Forest Management

According to Mr. VENKADESH, DFO Dindigul (Interview on 20.02.01) more than 75 villages where selected in Dindigul district to join the JFM program under the TAP (see chapter 2.3). The selection concentrates on areas with strongly degraded forest and a high dependence of the people on it. According to Mr. VIJAYAKUMAR, forester Batlagundu (Interview on 14.12.00), the JFM/TAP program was started in the study area in 1997 in three villages: Kombaipatty, Kulipatty and Pudur. In the first phase soil and water conservation and tree planting in the RF was carried out.
In the second phase credits where provided to individuals and the village community. The first covered milk cows, motorised spray tanks, sowing machines and bicycles.
The second covered the installation of threshing places, wells and the acquisition of a new funeral vehicle for the poor households to use free of charge. 70% of the credits provided have to be paid back. This money shall than be reinvested in village development (VENKADESH DFO Dindigul, Interview on 20.02.01).
The villagers are allowed to collect dead wood and Non Wood Forest Products (NWFP) (Mr. VIJAYAKUMAR, forester Batlagundu, Interview on 14.12.00). The protection of the Kadavakurichi is done in co-operation with the forest watcher and the VFC. The VFC can fine people using the forest if they do not belong to the village. If the villages do not use the forest according to the JFM agreement, they have to pay fines to the FD.

3.7 The PHCC and its work in the study area

The Palni Hills Conservation Council (PHCC) is a registered society and was founded in 1985 in Kodaikanal, a hill station in the Palni Hills. Their aim was to stop the deforestation in the Palni Hills and to proceed with the regeneration of the forests. To reach this aim, a massive tree-planting program was planned on dry land farms to meet the need of the people in the foothills and to reduce the pressure on the forest. To test the concept, five different places were selected and tree planting centres were set up. One of these areas was the Kadavakurichi. As early as 1988 the first nursery was established and raising and planting of seedlings started. To implement the aim of an improvement of the forest and a sustainable supply of the required products the “Kadavakurichi Interface Forestry Project” was started for a time span of ten years. To provide basic information and for fund raising purposes, a study on the vegetation of the RF, the land use in the area and the socio-economy of 11 out of the 19 villages, which were supposed to depend most on the forest, was conducted in 1991.
Swedforest and SIDA funded the project for 10 years. Soil and water conservation and tree planting programs on 100 ha private and 30 ha community land were carried out. In the villages which where depending most on the RF, several training groups, evening study centres and village planning communities were founded. Later, the work was extended to all 19 villages and the PHCC became one of the major institutions of the area. Since the beginning of the nineties the FD was asked to join and to install JFM programs. But the support was low and JFM only stared in 1997.
In the first five years the plantations developed nicely under the protection of the PHCC. Almost all of them disappeared however after the protection stopped. A management concept was lacking.

In the middle of the nineties the work in the villages increasingly gave way to routine work and became less effective. The last successes were the development of women sangam groups, which became independent of funds and the creation of a small credit system for local farmers in association with the State Bank of India, Nilakkottai. Due to internal conflicts in the project the work was almost inefficient by the end of the nineties and the aim to improve the vegetation of the RF was not reached. With the end of the funding in 2001 the project was stopped.

3.8 The concept of watershed

In order to investigate the relationship between the socio-economic situation and the state of the forest, the area was divided into five different subunits. Each of these subunits contains a part of the RF as well as a part of the adjacent area (figure 3.11). These subunits will be called "watersheds" (WS) from now on.
The term "watershed" can be defined in many ways. Today it is often used in the sense of "catchment" (PEREIRA 1989, BOTTRALL 1993), which means "… a body of land bounded above by a ridge or water divide and below by the level at which water drains from it" (COLMAN 1953). In this study the term is applied in the same manner.
According to the FAO (Unasylva 1991) the restoration of the European Alps, which started around 150 years ago, and the conservation movement in the United States in the 1930s initiated the modern watershed movement. It is a method of managing the landscape while involving its different components as well as the natural and anthropological settings. Since World War II, this way of landscape management had been implemented in many so-called developing countries although in developing countries a much higher impact of the inhabitants on the watershed and on its natural resources exists. This often made the management efforts a failure (Unasylva 1991). Nevertheless it is an often-used method to manage the land use and development and was found to be useful for the present study.
Due to the size of the area there are different terms in use, e.g. DOOLLETTE & MAGRATH (1990 in BOTTRALL 1993) distinguish the "typical" watershed (100000 – 200000 ha), the sub watershed (5000 – 15000 ha) and the micro watershed (500-2500 ha).
According to this definition, the subunits of the study area are micro watersheds (table 3.2), but to make the handling of the term easy, they shall be called "watersheds".

Watersheds of the study area

The borders of the watersheds were defined by the PHCC in their survey of 1991. They divided the area into five different catchment areas in the sense of the definition given above and according to the geographical relief. This included the Reserved Forest as well as the adjacent area.
Table 3.2 gives the details about the size and population of the different watersheds and figure 3.11 shows the watersheds in the study area.

WS	Surface in ha			People per ha (excluding RF)**	Village name	Distance to the border of RF in km
	Entire WS*	RF	Area excluding RF			
I	875	104	771	6,5	Mutharaiyar Nagar	1,3
					Veelinayakenpatty	1,5
					Papponayakanpatty	1,7
					Jeyanayakanpatty	2,4
					Maniakaranpatty	2,6
					Kamatchipuram	2,7
					Pudupatty	3,1
					Duraisamypuram	3,1
II	460	118	342	3,5	Kurumbapatty	0,5
					Mallanampatty	1,1
III	786	289	497	5,3	Kombaipatty	0,2
					Kulipatty	1,3
IV	1451	257	1194	2,2	Pudur	0,5
					Sivagnanapuram	1,2
					Bodiagoundanpatty	1,3
V	928	201	727	2,4	Andipatty	1,1
					Milakaipatty	1,3
					Muthukammapatty	1,4
					Musuvanoothu	2,0
I –V	4570	969	3531	3,7		

Tab. 3.2: Watersheds and villages, * PHCC (1991) ** calculated from PHCC (1998)

The watersheds differ in size and population density. WS IV is the biggest watershed, but it has the lowest number of people per ha. The highest population is found in WS I with 6.5 people per ha followed by WS III with 5.3. It includes also the biggest part of the Reserved Forest followed by WS IV.
The villages from WS I have the furthest distance of all villages to the border of the Reserved Forest. WS II and III are the closest to the forest.
The watersheds differ also in the land use pattern (table. 3.3)

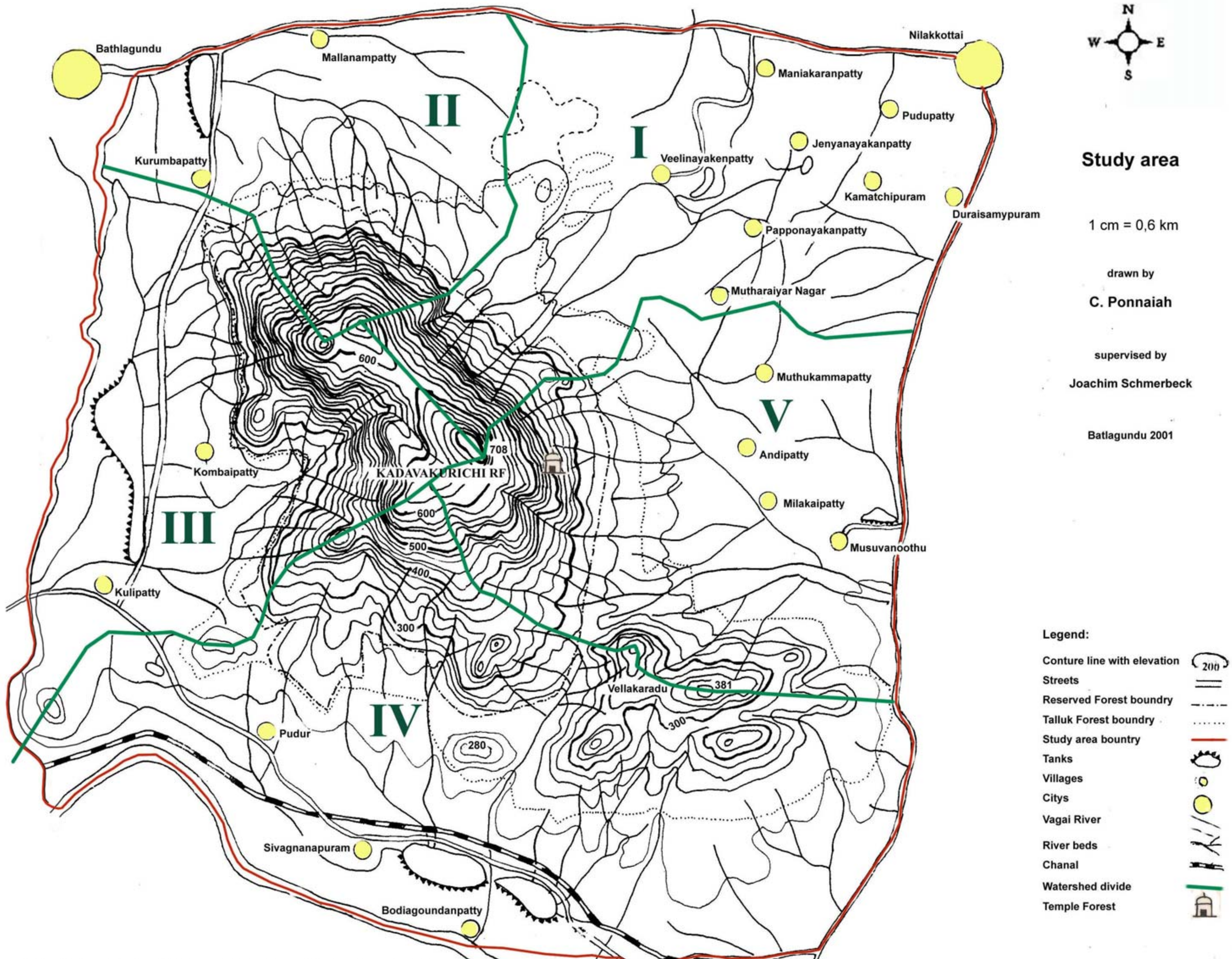


Fig. 3.11: Map of the study area with watersheds

Land use	Watershed				
	I	II	III	IV	V
Cultivated (%)	72	67	63	50	52
Out of this					
Irrigated (%)	24	70	67	49	53
Dry land irregularly cropped* (%)	17	15	3	3	<1
Dry land regularly cropped (%)	37	6	18	23	24
Uncultivable waste (%)	11	12	16	14	11
Taluk forest(%)	0	0	0	16	13
others	17	21	17	20	24

Tab. 3.3: Land use in the different watersheds excluding RF (source: PHCC 1991):
*in 1991 not ploughed more that 5 years

Watershed I has the highest portion of cultivated land followed by WS II and III. But they differ much in the ratio of irrigated land. WS I has a much bigger difference in cultivated land to land under irrigation than the other two. WS IV should have the highest water supply. It lies between the Vaigai River and the hillock and contains three villages. Two villages directly adjacent to the Vaigai, Sivagnanapuram and Bodiagoundanpatty, benefit from the river. But the proportion of the irrigated land is relatively low compared to the other watersheds. WS IV and V show a smaller proportion of cultivated land because they are the only watersheds including the small hillock containing taluk forest.

3.9 Fire on the Kadavakurichi hillock and the surrounding areas

Actual reports or studies about forest fires in the lower Palni Hills and the hillocks and hill ranges around them could not be found. Thus the following is based on the observation of the author during the stay in the study area and is limited to areas below 1000 m elevation.
On the lower Palni Hills and the hillock and hill ranges in the surrounding plains, fire and fire signs can be observed throughout the year in almost all forms of vegetation. The fires occurred mainly from February to September depending on the dryness of the grass layer. They are set at night-time and run as a line through the burned area (figure 3.12).

Fig. 3.12: Fire on the southern slope of the Palni Hills

The reasons can only be presumed and seem to vary from place to place. Creation of grazing ground, making the area more accessible and destroying trees and shrubs to make them suitable for fuelwood collection are probably the main motivations. The last point seems to be a contradiction. Approaching a burned area directly after a fire shows that it can be easily entered and trees and shrubs, relieved of their branches and thorns, can be harvested with less effort.

Fig. 3.13: Fuelwood collection after fire

Several patches, kept open with fire without an obvious practical reason[14] indicate that, beside the reason mentioned above, other motivations also play a role. This includes worshipping Gods and the believe that the creation of clouds through smoke leads to rain.

Fire was observed six times on the Kadavakurichi during the study period. The fires occurred mainly in WS I, II and III, and never in WS IV (table 3.4).

Month	Watershed	Elevation in m	Remarks
Feb. 1999	III	400-500	Small spot
June 1999	V	400-600	Small spots
July 1999	I and V	above 500	extensive
	III	above 600	extensive
Sept. 1999	II	above 400	extensive
Mai 2000	I, II	above 500	extensive
	III	above 600	extensive
July 2000	II	above 400	extensive
	III	above 600	extensive

Tab. 3.4: Fires on the Kadavakurichi RF during the time of data collection

The fires were mainly concentrated on the grasslands above 500 meters altitude. The biggest area they covered occurred in WS I (absolute and in relation to the size of the watershed). In WS III they affected mainly areas above 600 meters while in WS II they started often at 400 meters elevation. The fires in WS V were limited to small spots in areas with woody vegetation. In this watershed open patches dominated by grasses exist also, but they never burned during the time of observation.

Fig. 3.14: WS I and V one day after fire in July 1999

The forester in charge and the cricket team of Kombaipatty formed a fire-fighting group to stop the fires with hand tools. Other fire management systems do not exist.
In the frame of the socio-economic survey all persons questioned were asked about their opinion on the reason and effect of the fires. The results are shown in chapter 5.2.3.

[14] Far away from the places where cattle are kept, steep places touching the base of barren rock etc.

4 Methodology

4.1 Vegetation survey in the Kadavakurichi Reserved Forest

The aim of the vegetation survey was to make an inventory of the entire Reserved Forest (RF) to get information about the cover, structure and condition of trees, shrubs and herbal plants.

4.1.1 Maps

For the arrangement of the sampling plots, a map of the RF (scale of 1:10000) based on the SURVEY OF INDIA map 58 F/16, 1:50000 (1972) had to be made. The part of the map showing the study area was scanned into the computer and enlarged to a scale of 1:10000 from which the required map was drawn. From this map the size of the entire RF and of each WS was investigated with a graduated glass plate (see table 3.2).

4.1.2 Number, distribution and size of plots

Two different designs regarding the number and plot distribution were installed for the Temple Forest and the rest of the hillock. The first is a small Siva Temple situated on the eastern slope of WS V at an elevation of 377 m.

Temple Forest

The vegetation here differs strongly from the rest of the forest. An inventory of this small area was conducted as an approximation to the potential vegetation.

Figure 4.1: Thick vegetation with big trees of the Temple Forest

The borders of the little thicket on the periphery have been defined and the length of the borders measured. The total area defined as “Temple Forest” has a size of 0.15 ha.
Before the plots were demarcated, a buffer zone of 2 m to the border had been defined, its inner line was taken for the vegetation to be measured.
To make the results comparable to the entire vegetation survey, the same plot design was chosen for both (see below). In order to get enough plots demarcated, a distance of 10 meters between the centres of each plot was taken (see figure 4.2).

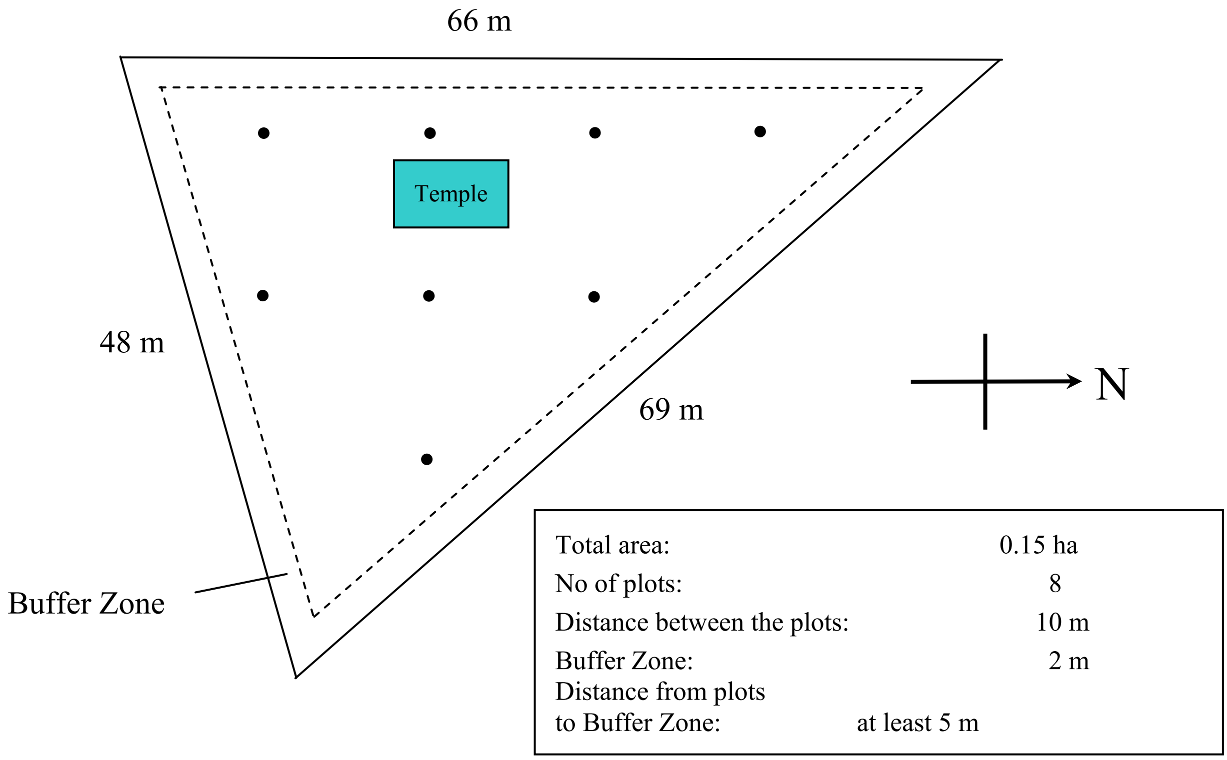


Fig.: 4.2: Layout of the Temple Forest plot distribution

The watersheds

It was necessary to find an inventory design, which provided the required inventory data of each watershed with the necessary precision and also allowed a floristic classification of the entire forest. SHARMA et al. (1983) have studied the minimal area of different forest types in South India. This study includes different phenotypes of the Dry Deciduous Forest (as classification of CHAMPION & SETH 1968, appendix 3.3). They suggest an optimal sample plot size for trees in the Dry Deciduous Forest (20 x 20 m) and for shrubs 9 m² (3 x 3 m). The shrub layer was defined as 0.5-3 m and the tree layer above 3 m in height.

In order to get inventory data for each WS and also for the entire RF, it was necessary to implement a design that provided an even distribution of the sample plots over the area and a sample area, which correlates with the size of each unit respectively. This made many survey plots necessary. To make sure that all locally found species are present in the vegetation survey, the inventory had to be made within one rainy season, in four months (mid of October 1999- mid of February 2000). Under these conditions the sample plots had to be kept as small as possible. In connection with the results from SHARMA et al. (1983) and regarding the average height of trees, which was around 2 m in the study area (see table 5.4), the plot sizes were fixed for herbal plants and shrubs to 9 m² (square 3x3 m) and for trees to 30.2 m² (circular).

On the basis of the available time for the vegetation survey the number of sampling plots was 500. These plots were spread in a grid pattern over the entire hillock. Each cross point of the grid represented the centre of a sample plot. With a total area of the RF of 969 ha, the calculated distance between two plots was 139 m. The distribution of the plots over the watersheds and the elevation belts is given in Tab 4.1.

Elevation	WS					
m a. MSL	I	II	III	IV	V	total
< 300	7	12	33	70	27	149
300-400	17	23	43	41	36	160
400-500	11	17	30	13	19	90
500-600	9	9	36	7	16	77
> 600	7	4	8	0	5	24
Total	51	65	150	131	103	500

Tab.4.1: Distribution of sampling plots by elevation and watershed

Each plot was demarcated with a compass and a 50-m steel tape measure. The distance between the plots was adjusted to the slope with formula 1:

$$x = \frac{139\text{m}}{\cos \lambda} \qquad (1)$$

x = distance between the plots in the field, λ = slope angle on measured distance.

4.1.3 Plot demarcation and design

From the measured point the 3 x 3 m-plot was installed as a square horizontal to the slope with the measured point at the centre. Ropes with a length of three meters, orientated at the corners of the square with an aluminium angle of 90°, were stretched (figure 4.3). This plot will be called "9 m²-plot" from this point on.

Figure 4.3: Setting of the ropes of the 9 m²-plot

To refine the estimation of the species and plant coverage, sub-ropes were laid parallel to the sides of the square at a distance of 0.5 meters. These small squares covered 2.8% of the total 9 m² (figure 4.4). In dense vegetation the sub-ropes could not always be laid out.

Figure 4.4: 9 m²-plot with subropes

The 30.2-m² plot was demarcated by a 3.1 m radius from the centre of the plot (measured point). Figure 4.5 shows the plot design for both plot sizes. The plot defined by the 3.1 m radius will be called the "30 m²-plot" in the following.

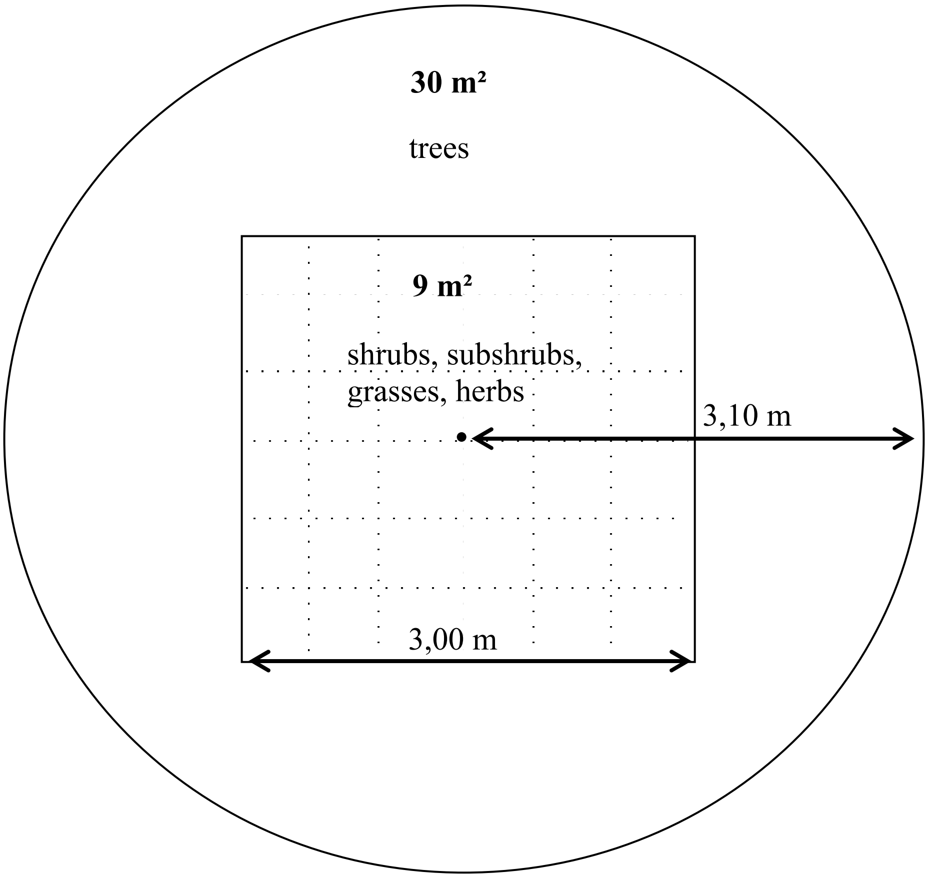


Figure 4.5: Layout of the plot design

4.1.4 Organisation and timetable of fieldwork

The vegetation survey was carried out with two groups of two helpers respectively. The constellation of the groups changed weekly to minimise errors caused by mistakes of the group members. Starting from Kombaipatty, the groups drove by moped to the border of the RF and reached the plots on foot. The time needed to reach each plot and to collect the data was noted respectively. The time recording was stopped after measurement of the last plot on each day.

	Survey except Temple Forest			**Temple Forest survey**		
	average	Max	Min	average	Max	Min
Reaching the plot in min	45	209	5	33	120	3
Data collection in min	209	247	6	59	74	4

Tab.4.2: Amount of time for data collection

4.1.5 Collected data

4.1.5.1 Measurement and collected data on plot level

Data to describe the site, the vegetation and the human impact on it were collected.

All data on coverage are related to the 9 m² plots and are estimated in 5% steps according to the following scale:

Steps	coverage in %
+	< 1
5%	1 - 5
10%	6-10
15%	11-15
•	
•	
•	
100%	96-100

Site parameters

WS

For each plot the attributed watershed was determined.

Slope

Measured in degrees with a gradometer as part of the compass.

Exposure

Measured in degrees with the compass.

Altitude

Meters above Mean Sea Level (MSL) taken with an altimeter.

Soil texture

Due to the skeletal soil it was only possible to specify the soil of the upper horizon. On the left and the right side of the 9 m²-plot a hole was dug and the soil was classified according to its texture as having one of four possible characters: rubble, sand, silt and clay according to the definition of SCHACHTSCHABEL et al (1989). Each soil texture description has three different characters while the last one is the most dominant.

Depth of soil

An iron rod of 50 cm in length was driven into the soil as deeply as possible beside the places where the soil was tested and the depth was measured. In only a few cases could the rod be driven in deeper than 50 cm.

Rock

Estimation of the area covered with bedrock.

Humus

At the holes where the soil testing was done, the different humus layers (L, Of, Oh, Ah, see HARTGE & HORN 1991 and SCHROEDER 1992) was specified. The depth of each layer was measured according to the following classes:

+	= < 0.5 cm
1	= 0.6-1cm
1.5	= 1.1- 1.5 cm
2	= 1.6-2 cm
etc.	

Vegetation

Biomass

Estimation of the area covered with above ground biomass.

Number of species

All species were counted.

Cover of species

The area covered was estimated for grasses, herbs and shrub species above 5% cover and for all trees, shrubs and climbers. This included also the cover from plants rooting outside the plot.

Dead wood

The areas covered by standing and lying dead wood were estimated. For the standing deadwood the number of pieces was counted and the average height and average diameter at root collar was measured (dead parts of living plants were not taken into account). For lying deadwood the average diameter of the three thickest pieces was taken.

Human and animal impact

Tracks

The area showing signs of human footprints or those of domestic animals was estimated.

Dung

The area covered by cow and goat dung was estimated.

4.1.5.2 Phytosociological data collection

The plants were collected and herbarium sheets were prepared. The identification was done mainly with the reference books of MATTHEW (1981-1999), BRITTO (1998) and ROA (1941). To prove the identification results, the herbarium was compared with the herbarium at the French Institute Pondicherry and the herbarium at the Anglade Institute of Natural History, Shembaganur.
To simplify the classification as used by MATTHEW the following key was used for the description of the plants found in the field (table 4.3).

Phenotype designation by MATTHEW	Classified as
Tree, shrub/tree	tree
Shrub, subshrub/shrub	shrub
Straggler, climber, liane, scandent shrub	climber
Subshrub, annual subshrub	subshrub
Culms	grass
Herb, vine, twiner	herb

Tab.4.3: Phenotype classification used in the study abstracted from MATTHEW (1981-1999).

The description "shrub/tree" for a species is given by MATTHEW (1981-1999) for tree species which resemble a shrub in shape after utilisation (cutting, grazing etc.) (MATTHEW 2001, personal communication). Such species were generally classified as trees. Only if the observation of the species in the field indicated that the classification as tree would be inadequate it was classified as shrub.

4.1.5.3 Plant measurement

In their growing pattern, climbers can appear as shrubs if they grow in the open field without other plants to climb on (for example *Pterolobium hexapetalum*). Due to this fact it was more practical for the data collection to group shrubs and climbers as shrubs. Shrubs and trees are from now on referred to as "woody plants". Due to the same measurement rules for subshrubs, grasses and herbs these types were grouped for measurement purposes as "herbs".
More information was required about woody plants. To reduce the effort of measurement somewhat, a classification into two groups, individuals (ind.) and non-individuals (n.-ind.) was done. Individuals were measured more precisely and were defined as:

- Trees: >50 cm in height
- Shrubs: diameter at root collar >= 1cm

To use the dbh as an indicator for the definition of tree individuals was ineffective, because a lot of trees did not reach the height of 1,3 meters. To use a height of 50 cm was found to be more suitable to divide the big individuals for an intensive measurement from the small ones. Shrubs occur very often as skinny plants with a height taller that 50 cm. A definition of shrub individuals by height would have increased the effort of measuring these plants, but small and compact shrub individuals would have been excluded.

Table 4.4 shows the measurement taken of the plants in the different plots (9 m² and 30 m²).

Measurements	9 m²- plot			30 m²-plots	
	shrubs		herbs	trees	
	ind.	n.- ind	n.-ind.	ind.	n.- ind
Height					
Height of the highest branch	•			•	
Average of the three highest branches	•				
Average of the three highest plants		•	•		•
Diameter					
dbh of the thickest trunk (measurement only if ≥ 1cm)				•	
Average dbh of the three thickest trunks				•	
Drc of the thickest trunk	•			•	
Average of drc of the three thickest trunks	•			•	
Number of trunks.					
Number of trunks at dbh ≥ 1 cm in diameter.				•	
Number of all trunks at root collar	•			•	
Shape of the crown					
Position of crown				•	
Eight crown radians	•			•	
Estimated Crown protection in % of the plot	• and tree				
Damage					
Type and intensity of signs of damage	•	•	•	•	•

Tab. 4.4: Plant measurements, dbh = diameter at breast height, drc = diameter at root collar

Height

Height was measured with a self-made wooden scale of 4.5 m in length with a 1 cm tolerance. The measurement was taken up hill and close to the plant to avoid slope influence. In case an individual was taller than 4.5 m, the scale was pushed up to the top of the plant and the distance between the lower end of the scale to the ground was added.

Diameter

The diameter was taken with a calliper rule. If it measured more than 7 cm, a girth tape was used.

Shape of the crown

Position of crown: The distance between the root collar and the middle of the first living branch.

Crown radii: Eight crown radiances in the direction North, Northeast, East, Southeast, South, Southwest, West, Northwest were measured. According to HUBER (1981) a measurement of eight crown radii is sufficient to calculate the crown projection. On average it does only vary up to 5% from the "true" crown projection assessed by HUBER (1981). The measurement was taken at the surface of the stem at the root collar of trees and from the middle of the plant with shrubs. The reach of living parts of the plant was measured with a tolerance of 1 cm. In case the crown was above the person doing the measurement, the "Tangential Look Up Method" ("Tangentiale Hochblick Methode", for details see HUBER 1981) was used.

4.1.5.4 Damage

For each individual and for non-individuals the damage caused by browsing, cutting and fire was recorded for each species. The damage level was classified into four classes as explained in table 4.5. Only if one of the damage types could be clearly identified a classification in the damage-classes of 2-4 was made.

Damage class	Damage level	Definition
1	non	No damage can be identified
2	little	Signs of damage can be identified, but it does not harm the development of the plant
3	medium	Signs of damage are clearly present. The plant is affected in its development and does not show its original shape
4	heavy	The plant is still alive, but almost removed

Tab. 4.5: Damage-classes of plants

Using this system of damage identification, damages which clearly influenced the plant in its growing habit and shape but which were healed out or weathered away, could not be recorded. This includes fire signs on grasses and shrubs, which were washed away with the first rain occurring after fire. Because of the relatively big root systems, compared to the rest of the plant, which was built up over the years, the plants are able to regenerate very fast through coppice (see also BRANDIS 1897 p. 8, CHAMPION AND SETH 1968, PASCAL 1986, own observation). The same holds for damage through cutting. The fast weathering process makes it often impossible to identify the rest of a branch as “cut” if a stem is left and the wound is not already healed.

Figure 4.6 (next page) shows trees of different species affected by different kinds and grades of damage.

4.1.5.5 Soil profiles

In addition to the soil data collection at the plots, eight soil profiles were taken covering the hillock. The places for the profiles where chosen to describe the different sites of the hillock. For each profile the horizons were described.


A B

C

D

E

F

G

H

Fig. 4.6: Damage classes of trees
A: *Euphorbia antiquorum* burned 3; B: *Commiphora berryi* burned 3; C: burned branches of B; D: *Commiphora berryi* cut 3; E: *Commiphora berryi* cut 4 (after fire); F: *Acacia planifrons* cut 4; G: *Euphorbia antiquorum* burned 4; H: *Commiphora berryi* browsed 4

4.1.6 Calculation of Vegetation Parameters

Crown projection and crown volume index

The crown projection was calculated with the "Pitch Circle Model" (Teilkreismodell) by HUBER (1981). This model gives sufficiently accurate results regarding the "true crown projection" defined by HUBER (1981). It calculates the area of each segment (pitch) of the crown projection based on two neighbouring radii.
A crown volume index was calculated using the height of the crown into the crown projection. The formula for the crown projection per individual (CP_I) is:

$$CP_I = \sum \frac{(rm_1{}^2 \cdot \pi)}{8} \qquad (2)$$

rm_I= arithmetic mean of two neighbouring radii.

The crown volume index per individual in m³ (CV_I) was calculated in the formulas 3 and 4:

Trees: $$CV_I = CP_I \cdot (h - hpc) \qquad (3)$$

Shrubs: $$CV_I = CP_I \cdot (h_a) \qquad (4)$$

h = height of individual in m, hpc = height of the crown base, ha = average height

To get the crown volume index of one species/phenotype for one plot, the sum of the crown volume of each individual belonging to this species/phenotype were summed up (formula 5):

$$CV_P = \sum CV_I \qquad (5)$$

Wood volume index

The amount of wood that an individual contains was only calculated for trees. Due to the lack of a reduction factor to calculate the solid wood for the tree species in the studied forest and their more shrubby habit, the exact amount of solid wood could not be calculated. Thus the following formula provides an index, which is assumed to correlate closely and positively to the actual wood volume (formula 6 and 7):

Wood volume index of each individual in m³ (WV_I):

$$WV_I = (r_0{}^2 \cdot \pi \cdot h \cdot n_0) \qquad (6)$$

where r_0 = radius of thickest stem at base in m, h = height in m, n_0 = number of trunks at the base (n_0 >= 3 set as 3)

Wood volume index of each plot in m³ (WV_P):

$$WV_P = \sum WV_I \qquad (7)$$

Biomass index for grasses and subshrubs

Because of their dominant role in the herbaceous layer and their correlation to the fire frequency, the volume of grasses has been calculated in the following way (formula 8):

$$GV = \sum sc \cdot sh \qquad (8)$$

GV= Index for the biomass of grasses, sc = species cover, sh = average height of species

Of the herbaceous layer, the subshrubs as the mainly used phenotype of this layer were analysed as well. The index for the amount of the subshrub biomass (SSV) follows formula 8.

Diversity

According to DIERSCHKE (1994) diversity can be defined in many ways. Here the species diversity of each plot shall be defined as showing the difference of the plant associations (α-diversity, see DIERSCHKE 1994, p 144). As an expression of the diversity the index of SHANNON (1948/1975 in DIERSCHKE 1994) was chosen. This index shows the variety in the specification of single elements of a system. Here the species coverage was used (formula 9):

$$H' = -\sum_{i=n}^{n} p_i \cdot \log p_i \qquad (9)$$

Whereby: $p_i = \frac{N_i}{N}$

H'= diversity, N_i = coverage of one species, N = Sum of the coverage of all species

H' is always positive. If all individuals belong to one species, H' becomes 0. The highest value for H' is achieved if p_i for all species is equal. The species with a cover lower than 5% were incorporated with a value of 1 %.
To form a picture where the vegetation is dominated by one or more species, the evenness was calculated out of the Shannon Index. According to DIERSCHKE (1994) it represents the ratio of the highest equipartition and is calculated:

$$E = \frac{H'}{H_{max}} \cdot 100 \qquad (10)$$

H'= diversity, H_{max}= highest H'

The value of the evenness lies between 0 and 100 and according to DIRSCHKE (1994) it indicates up to 40 the dominance of a single species along with a general scarcity in species. Above that value the number of species rises and the coverage equalsout.

4.2 Socio-economic Survey

To gather information on how the people living in the villages around the Kadavakurichi were using forest products, structured interviews with closed and open ended questions were made in all 19 villages in the study area. During the data collection, shepherds from outside the area with huge cattle herds used the areas adjacent to the Reserved Forest for grazing. These shepherds and their families lived in five temporary settlements in the study area around the Kadavakurichi Hillock. Observations led to the conclusion, that the interference between these shepherds and the forest was negligible. To gain information about the interference of these shepherds with the forest, semi-structured interviews on the basis of a guideline questionnaire were conducted. In addition, interviews with key informants in the forest context were carried out to get information about the actual forest management systems and influences upon them.

4.2.1 Selection of the households

Definition of household

In the present study, a household is defined as the group of related persons, who usually live together and share common cooking arrangements (regarding Census of India 1991 p. 3, MENCHER 1996 in DILLEN forthcoming).

Selection of the households

With the intention of concentrating the interviews on the households using the forest, a stratum sampling method was used. All households in all 19 villages were classified into four different strata:

- **Fuelwood collectors** (households using mainly fuelwood)
- **Cattle grazers** (households using the KV mainly for grazing)
- **Others** (households using mainly other products like green manure, medicinal plants etc.)
- **Non Users** (households not having used the KV in the last five years)

Households belonging to the first three strata are from now on called “users”, while households of the last stratum are called “non-users”. A household was classified as user, if it used the forest within the last five years.
According to FRIEDRICHS (1990), BORTZ (1993) and DIEKMANN (1995) such a separation of the total population in different strata minimises the variation of the analysed parameters within a stratum as compared to a fully random selection among the total population. The population within a stratum is well represented. It is presumed that the information about the parameters, on which the strata are defined, must be known to the whole population. The above mentioned authors refer to public statistics. Such statistics, however, do not exist for information about forest use in the study area. To solve this problem, the selection of each household to the four strata was identified per village by the PHCC staff who were in charge of the village. One or more persons from the village, who were believed to know the households and their habits, were involved in the selection process. According to their

strata the households were marked on village maps with a key consisting of a letter according to the stratum and a serial number. Villagers had drawn these maps during PRA-Programs of the PHCC. In most cases they had to be updated or redrawn. It was not possible to get village maps from the local administration. In villages with only non-users no maps were used. Here the households were counted and every tenth household was interviewed. From this count the number of households per user group, village and watershed was calculated (see table 5.13).
The sample sizes were taken proportionally to the size of the total population of each stratum, while the rate applied to the non-users was kept smaller:

Sample sizes:

Users	**Fuelwood collectors**	50%
	Cattle grazers	
	Others	
Non Users		10 %

FRIEDRICHS (1990), ATTESLANDER (1993), BORTZ (1993), DIEKMANN (1995) and QUATEMBER (1996), recommend a random selection of households/persons within a stratum. In order to simplify the work in the villages, an objective selection was chosen. Every household of the user group with an uneven number within a stratum was selected. For the non-user stratum every tenth household was selected. If the total number of households in one stratum and village was uneven, the number of households in the sample was rounded up.
Conducting the strata per village and rounding up the number of households within the sample in the case of an uneven total number led to a slightly higher sample size in some watersheds. The total number of users is shown in table 5.1.3.

4.2.2 The Interviews

4.2.2.1 Pre-test

To test the questionnaire for feasibility a pre-test was carried out in May 2000 in Viralimayanpatty, a village to the South of the study area, close to the Nagamalai RF, not included in the actual sample area.

4.2.2.2 Organisation and timetable of the fieldwork

The interviews were made from June to October 2000, usually in the morning between 7-10 am in the selected households, face to face with one member. After 10 am the people were at work or in the fields. Interviews could not be done in the evening due to the availability of the interview staff.
During an interview the questions were translated through an assistant into English. The author and a third person noted down the answers. The data were fed into the computer on the same day.

4.2.2.3 Structured interviews

Selection of the interview partner

In the user households the interview was conducted with the person who was mainly in charge of the forest use. If two different uses were practised by two different persons of one household, each of the persons was interviewed. Of a non-user household any adult person was interviewed.
The number of interviews per WS is given in Tab. 4.6. The break-up per village of the interviews is given in appendix 4.2.

WS	Fuelwood users	Cattle grazers	Others	User total	Non-user
I	45	9	1	55	102
II	15	3	0	18	24
III	46	15	44	105	43
VI	7	3	0	10	48
V	27	7	0	34	34
Sum	140	37	45	**222**	**251**

Tab. 4.6: Number of interviews per watershed

222 interviews in 218 user-households and 251 interviews in 251 non-user households were made.

The questions

The main topics of the questionnaire were:

1) Forest use:

- Products used
- Frequency, season and location of use
- Species, part of the plant and quantity used
- Shortage of product availability and season of shortage
- Other sources of product collection
- Purpose of product collection
- Reason for fire

2) Forest improvement:

- Personal and general opportunities for improving the forest
- Reason for and opinion on fire

3) Socio demographic data

- Number of household members
- Age, sex and caste of the interviewed person
- Occupation and employment
- Amount of cattle owned by the household
- Ownership of land
- Planted tree species on the land and reason for planting

For each different product used by a household, a new set of answers to the questions under point 1) was recorded.
In addition, the village, the watershed, the roof, the type of house and other observations were noted down. The whole complete questionnaire is given in Appendix 4.3

Non response

If a household did not respond to an interview or the household member could not be contacted, it was replaced by the next household with an even number, which had not been interviewed. In one village (Milakaipatty, WS V) the non-response rate was such that one household could not be replaced.
In cases where the interviewed person denied using the forest product because of which the household was allotted to a stratum, the affiliation to the stratum was verified by the PHCC-staff. In case a clear connection of the household with the RF in the last five years was not evident, the household was excluded from the stratum. If the use of the forest product was evident, “non response” was noted for this product.

Distribution of forest uses over the strata

All together 275 times a forest use was named. Table 4.7 shows the distribution of the different forest uses and strata.

Strata / Forest uses	Fuelwood	Grazing	Green Manure	Honey	Medical Plants	Fence Material	Thatching	Small Timber	Hunting	Roots	No Response	Total
Fuelwood collectors	126	2	5	5	3	3	6	3	0	0	12	165
Cattle grazers	11	31	0	0	1	6	1	1	1	0	4	56
Others	7	0	19	13	9	0	2	1	1	1	1	54
Total	144	33	24	18	13	9	9	5	2	1	17	275

Tab. 4.7: Distribution of named forest products in the different strata

The difference of 2 in the sums, between 140 households among the user group "Fuelwood" and the sum of the use "Fuelwood" and "Non Response" (138) results from two interviews in two households respectively. The same applies to the user group "Cattle grazers".

4.2.2.4 Semi-structured interviews

Transhuman grazers

The grazing of cattle together with nomadic movement is called "transhuman grazing" and can be found in many part of India (MISRY 1999). Five settlements of transhuman grazers were found in the study area. Two in WS I and one in each of the other watersheds except in WS IV.

Semi-structured interviews with a guideline questionnaire were done in all five settlements. The interviews were carried out on January 23rd 2001, face to face with one or more persons from each settlement. Questions on the following topics were asked:

- Frequency of visits to the study area
- Duration of stay
- Number of families in one settlement
- Type and number of cattle
- Used grazing areas
- Frequency and season of forest grazing
- Grazed species
- Statement about forest fires

Key informants in the forest context

Unstructured interviews with open questions were conducted with persons who play a key role in the forest management of the Kadavakurichi RF or in that region.

The persons were:

- Mr. Vijayakumar, forester in Batlagundu, date: December 14th, 2000
- Mr. R. Subramanian, Kombaipatty panchayat president and head of the Village Planning Committee, date: January 26th, 2001
- Mr. Venkadesh, DFO Dindigul, date: February 20th, 2001
- Mr. S. Reddy, DFO Kodaikanal, date: February 14th, 2001

Questions regarding the following topics were asked:

- Joint forest Management (JFM) and other forest programs in Tamil Nadu and the study area
- Forest fire
- Afforestation techniques

4.2.2.5 Calculation of the used amount

Each person was asked about the amount of the product used. The given amount was estimated by that person. To estimate the annually removed mass of each product from the forest, the frequencies of entering the hillock were broken down on a daily basis with the following index:

Daily	1.00
More that once a week	0.30
Weekly	0.14
More than once a month	0.07
Monthly	0.03

Tab. 4.8 Index to calculate the daily access to the RF

To get the daily quantity used of a product in each watershed, the figure given by the respondent was multiplied with the respective index in table 4.8 according to the mentioned access to the forest. Statements indicating a less than monthly use were not taken in account.

To get the amount of products utilised in the RF of the different watersheds, the average use per head and watershed was calculated from the total quantity of products used by the inhabitants of a watershed. The per capita amount of extracted products of persons using more than one watershed was distributed correspondingly.

To get the number of cattle entering the different watersheds daily, the cattle should have been counted in the forest itself. Reliable data would have demanded a high presence in the field, which could not be realised due to lack of time and limited financial resources.
To gain at least an estimate on how many cattle were accessing each watershed daily, the index of table 4.8 was multiplied with the number of cattle taken by the respondent to the RF. In case more than one watershed was frequented, this calculation was done correspondingly.

4.2.3 Observations

Besides the interviews and the forest survey, observations of forest use and practise were made and noted down. These observations were made unstructured. Small spontaneous interviews with people met on the hillock were also made. The frequency and reliability of these observations depended on the physical fitness of the author and staff, which was often limited due to the extremely exhausting fieldwork during the vegetation survey.

4.3 Analysis of the site and the human impact on the Vegetation

To test the hypothesis set up in chapter 1, vegetation parameters had been chosen and their dependency on site factors and on human impact was analysed.

The following parameters were chosen as explanatory factors (x-axis):

Altitude
Slope
Depth of soil
Percentage of rock
Exposure
Main soil texture
Watersheds

4.3.1 Coding of the non-metric variables

For using the non-metric variables in the logistic and linear regression models (see below) they need to be converted. This was done through indicator variables for a contrast coding. According to BORTZ (1993) a contrast coding is used in multiple regressions, because the magnitude of the difference between the contrasted groups of an indicator variable can easily be reconstructed. The exposure does not represent a metric scale and could not be used as such. To make the exposure suitable for analysis, it was converted with four indicator variables as follows in table 4.9:

exposure	eo1	eo2	eo3	eo4
0	+4	0	0	0
NW (271-360°)	-1	-1	0	-1
NE (1-90°)	-1	-1	0	+1
SE (91-180°)	-1	+1	-1	0
SW (181-270°)	-1	+1	+1	0

Tab. 4.9: Contrast coding of the exposure

To include the soil texture as a non-metrical variable in the data analysis, it was first reduced to its most important character (namely soil texture). This leads to five different soil textures, which were encoded using four indicator variables:

main soil texture	so1	so2	so3	so4
Rock	-3	-1	0	0
Rubble	-3	1	0	0
Sand	2	0	-2	0
Silt	2	0	1	-1
Loam	2	0	1	1

Tab. 4.10: Contrast coding of main soil textures

In the second hypothesis the influence of human impact on the vegetation was tested. The watersheds were taken as areas of different grades of human interference according to the results of the socio-economic survey. Fuelwood collection was the main forest use. Thus the watersheds were contrasted according to the intensity of fuelwood collection in the Reserved Forest of each watershed. In addition the plots from the Temple Forest as an area with the lowest human impact were coded separately. The codification is given in Table 4.11.

watershed	wo1	wo2	wo3	wo4	wo5
I	-2	-2	0	0	0
II	2	0	0	-1	-1
III	-2	1	-1	0	0
IV	2	0	0	1	-1
V	-2	1	1	0	0
Temple Forest	2	0	0	0	2

Tab. 4.11: Contrast coding of watershed

4.3.2 Correlation between the site factors

To avoid multicorrelation, it had to be tested whether some of the explanatory factors can be explained by other factors.
A coefficient often used to describe the correlation between variables is the Pearson's r (BROSIUS & BROSIUS 1995). It is a measure of association which may vary from -1 to +1, while –1 represents a perfect negative correlation, 0 a non correlation and +1 a perfect positive correlation. The higher the absolute value of r, the more the two variables correlate with each other.
The variables were tested in a regression analysis against each other. The correlation between the different variables was low. The highest value of the Pearson's r between two different variables was 0.56052 and only in three cases out of 66 combinations exceeds 0.5.
How strongly one parameter determined another is expressed by the square of the Pearson's r i.e., r^2. It represents the percentage of the variance in the dependent variable explained by the independent. For example r^2 of 0.25 of the independent variable (x) explains 25% of the variance of the dependent variable (y) (GARSON 2000).
According to GARSON (2000), explanatory parameters which are determined by one or more other explanatory parameters with $r^2 > 0.8$ can not be used together in a model as an independent variable to explain a dependant variable. The r^2 of the values of the regression did not exceed 0.31. Following this condition, all x-variables can be used in the model.
A bivariate correlation has a limited suitability for testing the presence of a multivariate correlation between the factors (GARSON 2000). Therefore each of the variables to be used in the model as explanatory factor were tested in multivariate regressions against all other explanatory factors. This procedure was an attempt to explain the variation of each factor against all other factors.

Table 4.12 shows the r² for each independent variable tested against all other variables.

Dependant variable (y)	Independant variables (x)	r^2
Altitude	slope; soil depth; % of rock; so1; so2; so3; so4; eo1; eo2; eo3; eo4	0.18
Slope	altitude; soil depth; % of rock; so1; so2; so3; so4; eo1; eo2; eo3; eo4	0.36
Soil depth	altitude; slope; % of rock; so1; so2; so3; so4; eo1; eo2; eo3; eo4	0.37
% rock	altitude; slope; soil depth; Exp.; so1; so2; so3; so4; eo1; eo2; eo3; eo4	0.45
so1	altitude; slope; % of rock; soil depth; so2; so3; so4 eo1; eo2; eo3; eo4	0.43
so2	altitude; slope; % of rock; soil depth; so1; so3; so4; so4; eo1; eo2; eo3; eo4	0.41
so3	altitude; slope; % of rock; soil depth; so1; so2; so4; eo1; eo2; eo3; eo4	0.17
so4	altitude; slope; % of rock; soil depth; so1; so2; so3; so4; eo1; eo2; eo3; eo4	0.07
eo1	altitude; slope; % of rock; soil depth; so1; so2; so3; so4; eo2; eo3; eo4	0.37
eo2	altitude; slope; % of rock; soil depth; so1; so2; so3; so4; eo1; eo3; eo4	0.04
eo3	altitude; slope; % of rock; soil depth; so1; so2; so3; so4; eo1; eo2; eo4	0.04
eo4	altitude; slope; % of rock; soil depth; so1; so2; so3; so4; eo1; eo2; eo3	0.03

Tab.4.12: r² of multiple regression analysis of the independent variables

The value of r² never exceeds 0.45. According to the threshold-value of 0.8 (value to exclude a variable from the model) all factors can be used together in one analysis.

Influence of the time of measurement on the vegetation during data collection

The growth of grasses, herbs and subshrubs is due to triggered precipitation and only stops if the climatic conditions are too dry or hot which usually does not happen between October and February. At the beginning of the data collection, rainfall was sufficient to lead to the development of the herbal layer, which continued to grow.

Data collection in the watersheds was not distributed evenly over the period of fieldwork. Data in WS II were obtained in the beginning, in WS IV mainly at the end and in WS III during the whole of the data collection period (Table 4.13).

Time of data collection	Watersheds					
	I	II	III	IV	V	I - V
Oct. 99	-	39	39	1	1	80
Nov 99	45	26	32	-	29	132
Dec. 99	5	-	32	8	73	118
Jan 00	1	-	33	88	-	122
Feb 00	-	-	14	34	-	48
Total	51	65	150	131	103	500

Tab.4.13: Number of plots surveyed in different months

Thus a correlation between the point of examination and the stage of the development of the herbs, especially grasses, is likely.

To test this correlation, all days from the beginning to the end of the vegetation survey were numbered in ascending order and the respective number was assigned to each plot according to the day of data collection. The correlation between the grass index and the date of data collection was tested with a linear regression. It was not significant on a 0.05 level.

4.3.3 Chosen models for the hypothesis testing

In order to test if and how much the site and human impact influences the formation of vegetation, the following parameters were chosen as dependent variables to be explained (y-axis):

- Percentage of biomass cover
- Wood volume of trees (WV_P-tees)
- Crown volume of trees (CV_P-trees)
- Crown volume of shrubs (CV_P-shrubs)
- Biomass index grass layer (GV)
- Biomass index subshrubs (SSV)

A linear regression model was chosen to test the correlation between the site factors/human impact and the vegetation formation (see below). Because all vegetation parameters showed zero values on a considerable numbers of plots, the linearity assumption is destroyed and the linear regression is not suitable (MADALLA 1983, AMEMIYA 1984). The break of linearity could also be seen in the distribution of the residuals[1] of the analyses with the available data including the zero values. It gave a picture like DRAPER & SMITH (1981 in EL KATEB 1991, p. 38) show it for models, where the assumption of linearity is not fulfilled.
A simple exclusion of plots, which show a zero value for the tested vegetation parameter (y), would lead to a loss of information. To avoid this, a logistic regression was used to test how the site factors determine the probability whether the value of the tested variable in a given plot (y) will become zero or not (yes/no). Only the plots, which did not show a zero value for the tested parameter were included in the linear regression.

[1] A residual is the difference between the measured value and the value predicted by the model, the error of the estimation so to say. The residual distribution of a logistic regression should, regarding HOSMER & LEMESHOW (1989), show a normal distribution with an average of 0 and a standard deviation of 1. Not one of the tested variables showed a distribution behaving like that. Their variation from a normal distribution indicate the disability of the model to explain the event of a 0 value of the used parameters.

Logistic regression

The LOGISTIC procedure of the SAS statistical program allows the analysis of binary response data by a logistic regression based on the method of maximum likelihood (SAS Institute 1990, p. 1072). It results in parameter estimates, which enable us to calculate an estimated value (logit-value). The logit-value can then be used to compare the probability of an event (zero value yes or no) with the given site factors (explanatory factors) as:

$$\text{Logit}(w_i)=b_o+b_1x_1+b_2x_2+\ldots+b_ix_n \quad (11)$$

Logit(wi)	values to be placed in the logistic function (see below) which allows the attribution of estimations in the interval of 0 to 1.
b_o-b_i	regression coefficients
x_1-x_i	explanatory factors

To get the probability leading to the classification of Yes or No regarding the zero value, the Logit-value has to be implemented in the logistic distribution function (figure 4.7), which gives predicted values within an interval between 0 and 1. This function is based on the formula:

$$w_i = \frac{1}{(1+e^{-\text{Logit}(w_i)})} \quad (12)$$

w_i	estimated probability for a zero value of a plot
Logit (w_i)	predicted Logit value according to formula x
e	2,7182818

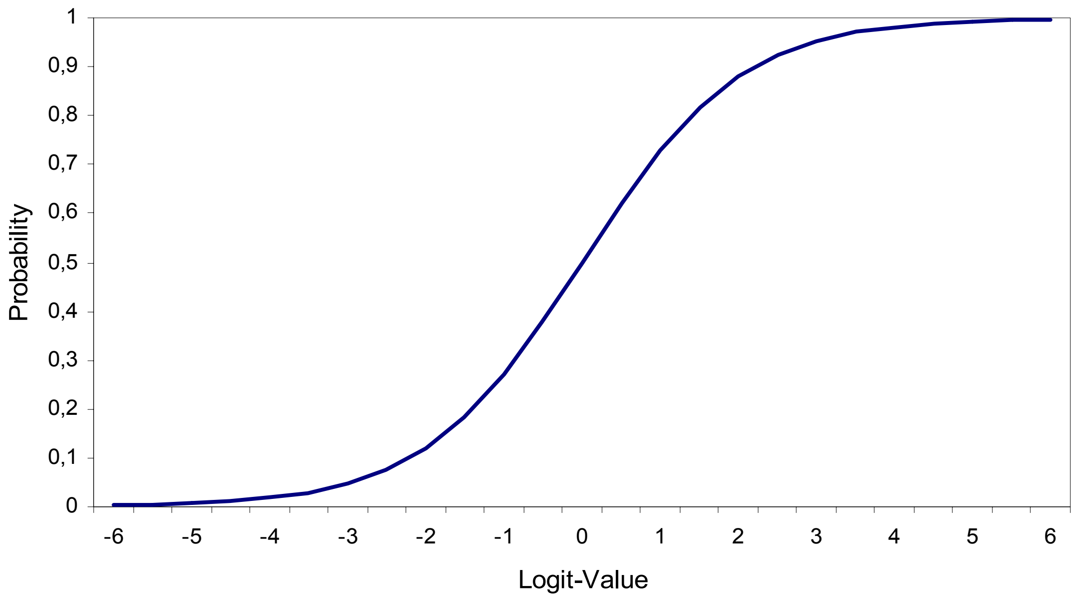


Fig. 4.7: The logistic function

The value is the predicted probability with which a certain y-variable for a plot gets a zero value or not (yes/no). It lies somewhere between 0 and 1. In order to classify observations into one of these two categories, a critical probability value has to be set. The LOGISTIC procedure of the SAS program sets a default value of 0.5. If the number of the observed 0 events is too small, the model does not give valid values. Exemplary calculations have shown that the ratio of actual zero values to non-zero values has to be at least 1:5 to produce valid values. To achieve this, the definition of "zero value" was set for the different values as given in table 4.14.

Parameter	Observed as 0 if	Observations	
		0	not 0
WV_P tree	≤ 0.003	101	407
CV_P shrub	= 0	181	327
SSV	≤ 0.045	295	213
GV	= 0	163	345

Tab.4.14: Marginal value and number of observations for 0 values

The plots for calculating the crown volume (CV_P) of trees had been selected with regard to the definition of WV_P for trees. For the coverage of biomass the logistic procedure was ignored because only five plots showed a value of 0.

Linear regression

The linear regression analysis has been used in many silvicultural studies and proved suitable (EL KATEB 1991, AMMER 1996/2000, KÜSTER 2000, MUJICA 2000). The principle of the multiple linear regression is supposed to be well known and will thus not be explained here (for details see BACKHAUS et al 1987, EL KATEB 1991, BORTZ 1993, BROSIUS & BROSIUS 1995 and others). Plots with values for the standardised residuals outside the interval –2 to 2 were defined as outlier values and were excluded from the calculation. This was done in steps while the interval was reduced from an absolute value of 3.5 in four steps of 0.5 to a value of 2. For each step only the site factors which were significant on a 0.05 level where accepted. In order to clearly fulfil the assumption of linearity between explanatory and explained variables, a logarithmic transformation of the explained variables was done (BACKHAUS 1987). The logarithmic transformation can not be done for 0 values. To transform the parameters, which dropped out of the logarithmic procedure, 0.0001 was added to each value.
In this way an adequate analysis of the determination power of the site and the human influence on the vegetation structure could be made.

4.3.4 Used software

The descriptive analysis of the vegetation and socio-economic data was done with MS Access 97, MS Excel 97 and SPSS 10.0 for windows. To calculate the logistic and linear regression the statistical software SAS was used.

5 Results

5.1 Vegetation survey of the Kadavakurichi RF

5.1.1 Site factors

The site conditions on the hillock were almost equal[1]. The clearly dominant soil texture was sand. It occurred in 80% of all plots. Most of this sand was silty (55%) followed by rubble sand (27%). In more than 96% of the cases the depth of the soil did not exceed 40 cm. The installed soil profiles showed a depth between 66 and 100 cm up to the basic rock, while a stony horizon starts between 0 and 21 cm with a thickness of 12 to 90 cm. This indicates that the root zone was deeper than measured on the plots, but still rather shallow. 87% of the plots showed basic rock on the soil surface. 20% were covered to more than 40% with rock. The highest ratio of plots with no rock cover occurred in WS IV, V and III and was predominantly situated in the flat areas.

The Kadavakurichi has a steep profile. Around half of the plots were steeper than 20 degrees with an almost equal distribution to the watersheds. WS IV and V have with 19 and 16% respectively the highest ratio of flat areas. The main difference between the watersheds was the exposure. Northern directions dominate in WS I and II while WS IV was mainly exposed to the South. The eastern and western directions are concentrated in WS I, V and III respectively.

The Temple Forest does not differ in soil texture, soil depth and rock cover from the remaining forest. It had a NEE exposure and a slope of 22°.

5.1.2 Species

Altogether 149 species out of 42 families were found on the 500 plots[2]. With 46 species (31%) trees occurred most frequently. Herbs came second with 34 species (23%). The total herbaceous layer in the Kadavakurichi, composed of herbs, grasses and subshrubs, contained 47% of all species. The woody plants together (trees, shrubs and climbers) represented 53% (Fig 5.1).

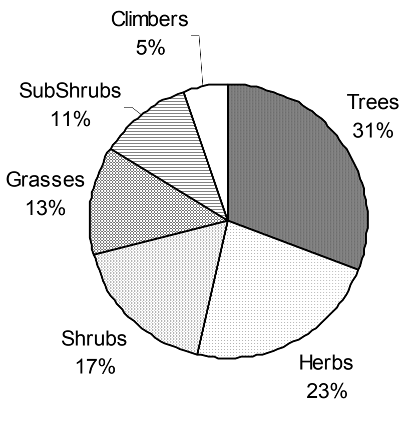


Fig.: 5.1: Ratio of species

[1] The distribution of the 500 installed plots to several site factor categories is listed in table appendix 5.1.
[2] A list of all species found on the hillock is given in appendix 5.2

In the Temple Forest 25 species occurred of which 13 were trees, 9 shrubs, 2 subshrubs and one grass. Four tree species occurred only here. Table 5.1 shows the difference in main species of Temple Forest and the remaining hillock.

	Temple Forest	Watersheds
	Species occurring in more than one plots (number of plots)	Species occurring in more than 10% of plots (ratio in %)
Trees	*Lepisanthes tetraphylla* (6) *Albizia amara* (2) *Commiphora berryi* (2) *Diospyros ebenum* (2) *Pleiospermium alatum* (2) *Sapindus emarginata* (2)	*Commiphora berryi* (68) *Euphorbia antiquorum* (55) *Acacia planifrons* (15) *Acacia horrida* (9) *Acacia spec 1* (8)
Shrubs	*Flueggea leucopyrus* (5) *Coffea wightiana* (4) *Sarmenilla obsticifolia* (C) (4) *Capparis sepiaria* (C) (2) *Jasminum* sessiliflorum (C) (2) *Jasminum trichotomum* (C) (2)	*Flueggea leucopyrus (37)* *Acalypha fruticosa* (24) *Pterolobium hexapetalum* (C) (20) *Jasminum trichotomum* (C) (20) *Jasminum sessiliflorum* (C) (19) *Capparis* sepiaria (C) (17) *Catunaregam dumetorum* (14) *Canthium coromandelicum* (12) *Coffea wightiana* (11) *Grewia tenax* (11)
Subshrub	none	*Barleria longiflora* (15) *Ocimum tenuiflorum* (12)
Herbs	none	none
Grasses	*Themeda cymbaria* (2)	*Chrysopogon fulvus* (28) *Themeda cymbaria* (27) *Heteropogon contortus* (18)

Tab. 5.1: Main species (C = Climber)

In the watersheds *Commiphora berryi* occurred in 68% of all plots and was therefore clearly the main species. The second most common tree species was *Euphorbia antiquorum*, followed by *Acacia horrida*, *Acacia planifrons* and *Acacia spec 1*. The last could be synonymous with *Acacia planifrons*, but due to the lack of flowers a clear identification was not possible. These species are all armed. The remaining tree species were represented in less than 10% of all plots and almost 75% of all tree species occurred in even less than 2%.

The tree species in the Temple Forest are almost completely different. From the dominant tree species in the watersheds only *Commiphora berryi* occurred here in two plots with a low coverage (appendix 5.4). The dominant species in the Temple Forest was *Lepisanthes tetraphylla* which not apear in the watersheds. The next frequent species were neither rare in the watersheds or did not occur there at all.

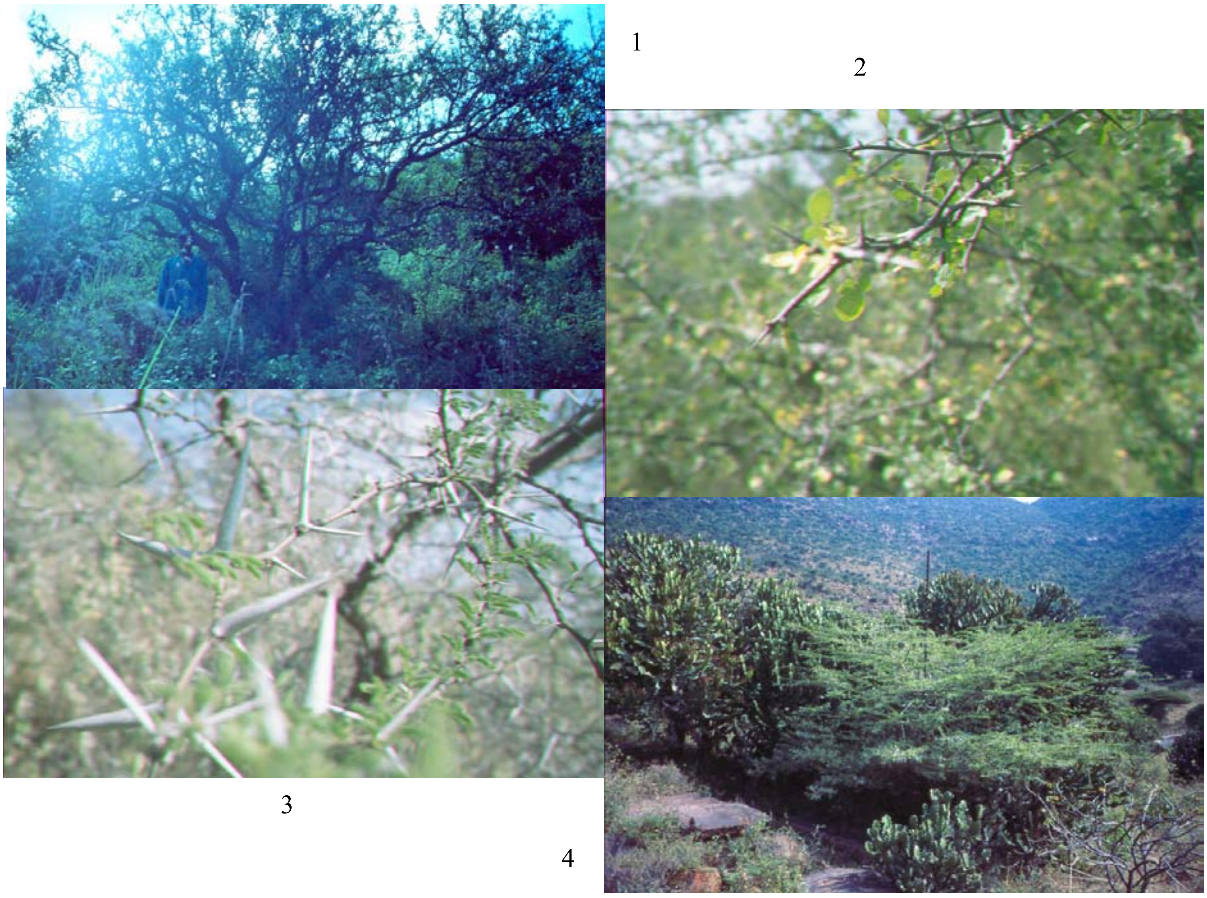


Fig 5.2: The most common tree species in the Kadavakurichi RF forest: 1: *Commiphora berryi*, 2: branch of *Commiphora berryi*, 3: thorns of *Acacia horrida*, 4: left *Euphorbia antiquorum*, right *Acacia planifrons*,

Shrubs

The diversity of species occurring in more than 10% of the plots in the watersheds was higher among the shrubs than among the trees. WS I and III had the highest number of species (9 and 10 respectively). This is remarkable in the case of WS I which had the second lowest number of plots (see also table 4.4). The dominant shrub species was *Flueggea leucopyrus* followed by *Acalypha fruticosa*, *Catunaregam dumetorum* and *Canthium coromandelicum*. Often represented climbers were *Pterolobium hexapetalum, Jasminum trichotomum*, *Jasminum sessiliflorum* and *Capparis sepiaria*.
The frequency of the species among the watersheds did not differ much. In all watersheds *Flueggea leucopyrus* was the most frequently occurring shrub species followed by the two *Jasminum* species in WS I and II and by *Acalypha fruticosa* in WS IV and V. WS II makes an exception. Here *Acalypha fruticosa* occurred in slightly more plots than *Flueggea leucopyrus*.

Subshrubs

The most dominant subshrubs in the watersheds were *Barleria longiflora* and *Ocimum tenuiflorum.* The former was also among the species in the Temple Forest where subshrubs occurred only in one plot.

Grasses

The main grasses are *Chrysopogon fulvus,* the tall and often-used *Themeda cymbaria* and *Heteropogon contortus*. *Themeda cymbaria* dominates on the frequently burned, open areas. It was the most common grass in WS I, II and III while it occurred in WS IV only in a relative small number of plots. It was also the only grass species in the Temple Forest where it occurs in two plots which are exposed to fire from time to time.

5.1.3 Diversity

The average Shannon Index among the 500 plots was 0.69 and showed almost no difference between the watersheds. In the Temple Forest the diversity with an average Shannon Index of 0.61 was the lowest in the entire forest. The average evenness among the plots indicates with a value of 64.1 that more than one species dominated the vegetation. The watersheds I, II and V showed with almost 70 the highest evenness while in the vegetation of WS III and IV the evenness among the dominant species was with a value of 60 slightly reduced. The average evenness of the Temple Forest lied with 66.5 near to the average of the remaining forest.

5.1.4 Vegetation structure

The vegetation of the watersheds showed an open structure. On the one hand almost no plot was completely barren and only less than 20% were covered less than 40% by living plants. On the other hand only 30% were covered to more than 81% with biomass. The situation in the Temple Forest was totally different. Of the eight plots five were covered to more than 80% and no plot to less than 60% with biomass.

5.1.4.1 Number of trees and shrubs

Among all watersheds the forest had 1223 trees per ha, while WS III showed the lowest number and WS I the highest (table.5.2). In the Temple Forest many more trees could be counted. The number of trees in the eight plots extrapolated to the hectare results in 1875 trees ha^{-1}. This exceeds the average number for the watersheds by 50%. As it will be shown below, it is not merely the number of trees that characterises this little stretch of forest.

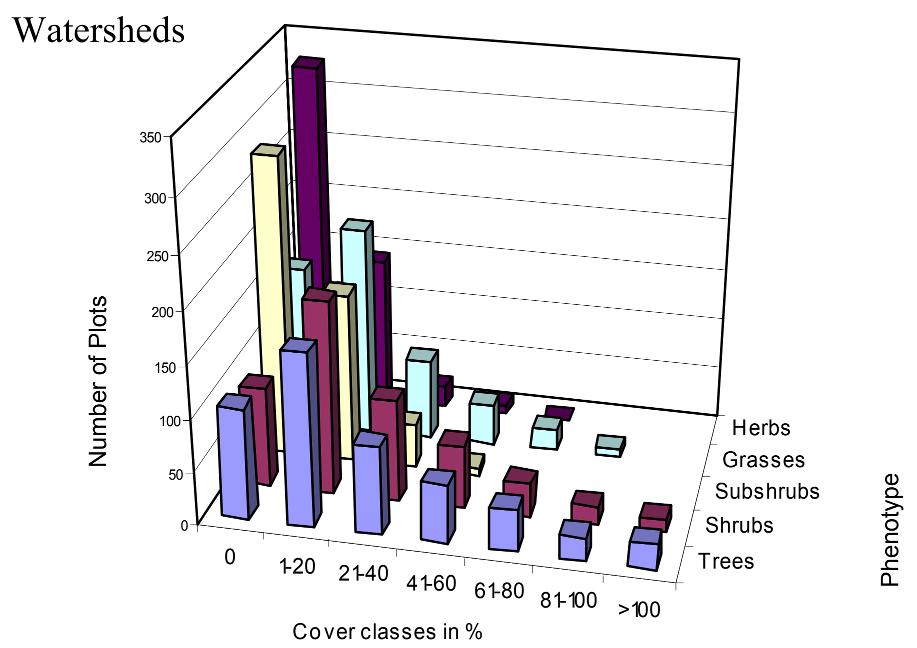
	Watersheds						Temple Forest
	I	II	III	IV	V	total	
Trees	1435	1294	1016	1353	1209)	1223	1875
Shrubs	8171	5880	6700	5123	6214	6233	5000

Tab. 5.2: Trees and shrubs per ha

In the watersheds the number of shrubs was five times higher than the number of trees. However, the ratio narrows in the Temple Forest to almost half.

5.1.4.2 Cover of phenotypes

Figure 5.3 shows the distribution of the various live forms to different cover classes in the watersheds and in the Temple Forest. The open structure of the vegetation of the Kadavakurichi is visible. All phenotypes were found mainly in the lower cover classes. The situation in the Temple Forest was completely different. Considering figure 5.3 one has to be aware of the different number of plots in the Temple Forest.



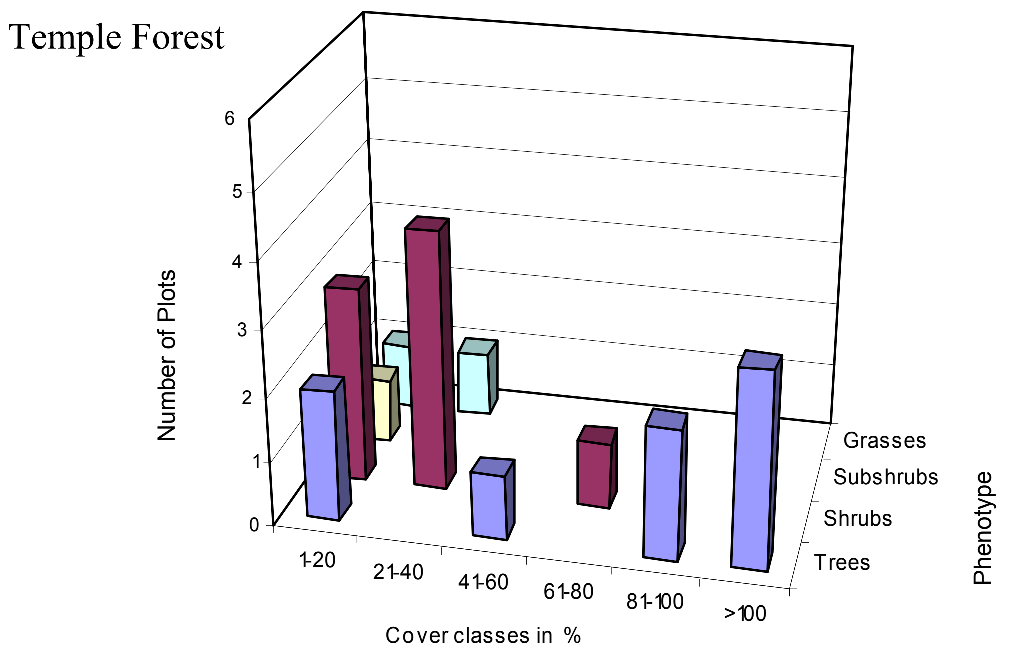


Fig. 5.3: Covering of the watersheds and the Temple Forest by the different phenotypes

Trees

Trees occurred in 92% of all plots of the watersheds but the area they covered was small. Half of the plots showed a tree cover between 1 and 40% (figure 5.3). Only 10% of the plots were covered to more than 81% with trees. The average tree cover was 31%. This makes the Kadavakurichi RF an open forest according to the definition set by the GOVERNMENT OF INDIA (1999) with a 10-40% crown density.
Among the watersheds, WS III with 29% had the highest portion of plots without trees, followed by WS I with 24%. The biggest portion of plots with a low tree cover between (1-20%) was found in WS II followed by WS III and I. These are the watersheds where most and biggest fires were observed in the study period. By far the biggest portion of plots with a tree cover above 81% showed WS IV and V. They exceed WS II and III having 14% and 15% respectively by almost three times this amount. WS I had almost no plots in the cover classes above 81%.
Among the species *Commiphora berryi* was the most frequent one among all cover classes in the watersheds followed by *Euphorbia antiquorum* in the cover classes below 80% and by *Acacia planifrons* above 80% coverage[3].
The vegetation of the Temple Forest was clearly dominated by trees. Five out of eight plots showed a tree cover above 80% while *Lepisanthes tetraphylla*, *Pleiospermium alatum* and *Atalantia monophylla* showed the highest values.

Shrubs

Shrubs were represented in 73% of the plots in the watersheds yet almost half showed a shrub cover smaller than a fifth of the plot area (figure 5.3). On average, shrubs covered 12% of the plot area. WS I had the highest ratio of plots with a shrub cover above 80% while WS IV and V had with 27% and 21% respectively the greatest portion of plots without shrubs.
Single shrub species did in general not cover more than 20% of a plot. *Pterolobium hexapetalum* showed the highest ratio in the cover classes of 20 to 80%. The highest proportion of these plots was in WS I with 16%, whereas the lowest was in WS II with none.

The dense tree cover in the Temple Forest did not lead to a smaller average cover of shrubs. It was with 29% much higher than in the watersheds. But the range was small. Only in one case it exceeded 40%.

Subshrubs

Only 40% of all plots contained subshrubs. In WS I the empty plots with 73% showed the highest ratio. Here subshrubs covered never more than 20%. WS III, IV and V showed an almost similar distribution of the cover classes. Between 44 and 47% of the plots contained subshrubs and in 10-15% they covered more than 20%.
In the Temple Forest subshrubs were found in only one plot with a cover of 10%.

[3] The cover of a phenotype represents the sum of the species cover

Grasses

The herbal layer consisted to the greater part of grasses. They occurred in almost 70% of all plots and with 22% showed a higher average cover than the shrubs. This is mainly due to the plots in the cover classes above 61%. The smallest ratio of plots without a grass layer had WS I with 18%, followed by WS II with 25%. WS IV had clearly the highest percentage of plots without grass. Of the plots with a grass cover above 60%, WS I and V showed the highest ratio.
A clear pattern in the distribution of the cover classes shows in the relation to altitude. Plots with no grasses had the highest ratio at the bottom. This ratio became constantly smaller with increasing elevation. The same was valid for the small cover classes while the ratio of plots with a grass cover of more than 60% increased from almost 0 at the bottom to 25% above the 600 m level.

In the Temple Forest *Themeda cymbaria* was the only grass species that occurred in two plots that had been burned previously, with a cover of 20 and 30% respectively.

5.1.4.3 Structure of individuals

Trees

The Temple Forest as the part with the lowest influence by man gives a picture about the dimension trees can reach on the Kadavakurichi. Within the Temple Forest four big trees dominated. None of them occurred in the relatively small plots that had been intended for examination of the shrub vegetation in the watersheds. Table 5.3 gives the structural parameter for these trees.

Species	Height (m)	Crown base (m)	Diameter breast height (dbh, cm)	Diamter root collar (drc, cm)	h-drc ratio	No of trunks at dhb	Number of trunks root collar	Crown volume index	Wood volume index
Acacia leucophloea	12.0	0	30.5	36.8	33	1	1	726.82	1.28
Azadirachta indica	10.2	3.82	49.8	53.5	19	1	1	543.42	2.29
Azadirachta indica	9.3	2.7	42.2	44.0	21	1	1	205.88	1.41
Drypetes sepiaria	7.25	0.8	58.2	72.1	10	1	1	109.28	2.96

Tab. 5.3: Structural parameters of the four big trees in the Temple Forest

Not one tree in the entire forest had a crown like one of these trees. The values for height, dbh, drc, crown volume and wood volume were a multiple of the average of the trees in the remaining forest (table 5.4). Even outside the measured plots in the remaining forest, no tree of these dimensions could be found. They showed a straight growth with only one trunk at the bottom and at the dbh. Noticeable is the very small h-drc ratio. It indicates a relative strong radial increment compared with the growth in height. The influence of fire or cutting on these trees can be excluded. Therefore the reason for their form appears to be in the low side pressure through other trees or in a general limit in the height increment. However, these trees are a good indicator for the growth potential of trees at the Kadavakurichi RF.

Table 5.4 shows average values for different parameters for the measured trees in the 30 m² plots and the wood volume per ha.

	Watersheds						Temple Forest
	I	II	III	IV	V	total	
Measured ind.	189	206	405	435	328	1563	38
Height in m	1.78 (0.80)	1.9 (1.01)	1.79 (1.08)	1.91 (1.04)	2.2 (1.2)	1.92 (1.07)	4.04 (2.43)
Crown base in m	0.53 (0.57)	0.43 (0.48)	0.51 (0.58)	0.53 (0.54)	0.69 (0.75)	0.55 (0.61)	1.02 (0.89)
Dbh in cm, thickest trunk	2.42 (3.7)	3.23 (3.97)	3.75 (5.09)	3.88 (4.79)	4.38 (5.47)	3.69 (4.84)	4.95 (3.76)
Drc in cm, thickest trunk	6.21 (4.02)	7.53 (4.52)	8.31 (6.44)	8.49 (6.53)	9.00 (7.14)	8.15 (6.21)	8.11 (6.23)
h – drc ratio	33 (15.05)	30 (18.19)	29 (20.12)	30 (21.72)	33 (20.50)	30 (19.93)	61.86 (27.56
Number of trunks at dbh	1.23 (1.64)	1.27 (1.49)	1.10 (1.67)	1.48 (2.26)	1.77 (2.20)	1.38 (1.96)	3.00 (2.77)
Number of trunks at root collar	1.46 (1.8)	1.46 (1.00)	1.35 (1.14)	1.36 (1.00)	1.74 (1.44)	1.46 (1.26)	1.92 (1.28)
Crown volume Index m³	3.36 (5.15)	8.13 (21.02)	7.51 (19.00)	9.14 (31.74)	10.36 (17.71)	8.14 (22.46)	27.98 (50.43)
Wood Volume index m³	0.01 (0.02)	0.02 (0.03)	0.03 (0.06)	0.04 (0.13)	0.05 (0.10)	0.03 (0.09)	0.07 (0.11)
Wood volume index m³ ha^{-1}	20	26	26	40	50	36	108

Tab. 5.4: Structure parameters of trees (average), *(standard deviation of mean)*, dbh = diameter at breast height, drc = diameter at root collar

All parameters in table 5.4 point out the suppressed formation of the forest in the watersheds. The average height of all trees was not even 2 meters, while the crown starts on average at 55 cm. In fact, in 90% of all measured trees the crown begins below 1,3 meters. Only 893 trees showed a bigger dbh than 1 cm. The thickest trunk at the dbh, on average, did not reach 4 cm while the one at root collar was twice as big. The ratio of height to diameter is a good indicator of the shape of the trees. The smaller it is the more compact is the shape of the tree[4]. Table 5.4 gives the ratio of the height to the diameter at root collar and not to the dbh as usual. But still, the average of 30 is very small and fits to that of solitary trees.

The number of trunks at dbh and at the root collar was an average of 1.46 and 1.38 respectively. The high standard deviation indicates that more than one trunk was common among the trees. But even with more than one trunk the wood volume was low on average. The standard deviation mirrors here a relatively wide variation.

The trees in WS IV and V on average had longer trunks and a higher wood and crown volume while the ones in WS V were the tallest in the entire forest. These two watersheds show also the highest wood volume per ha. WS I and III clearly had the smallest trees. They showed the least height and the lowest wood and crown volume.

In the plots of the Temple Forest trees were generally higher and thicker, contained more wood, had a much bigger crown and more trunks than the trees of the remaining forest. The wood volume index per ha was three times as big as the average value for the watersheds. The data in tables 5.3 and 5.4 and the similar site conditions of the Temple Forest compared with the remaining forest make it most likely that the difference in the vegetation structure is a result of absence or presence of human activity.

[4] It varies approximately between 70 and 95 (see also BURSCHEL & HUSS 1997)

Shrubs

The small difference between the average height between shrubs and trees shows the poor vertical structure of the forest (table 5.5).

	Watersheds						Temple Forest
	I	II	III	IV	V	total	
Measured ind.	160	155	332	230	252	1129	21
Height in mean(mean)	1.24 *(0.66)*	1.40 *(0.63)*	1.14 *(0.68)*	1.52 *(0.83)*	1.57 *(0.83)*	1.36 *(0.79)*	1.98 *(1.84)*
Drc in cm, average of the three thickest	2.16 *(1.39)*	1.95 *(1.23)*	1.88 *(1.06)*	2.27 *(1.28)*	2.01 *(1.10)*	2.04 *(1.20)*	1.58 *(0.99)*
Number of trunks at root collar	2.04 *(1.62)*	2.37 *(2.23)*	2.64 *(3.28)*	2.60 *(3.29)*	2.83 *(2.77)*	2.55 *(2.86)*	3.86 *(3.57)*
Crown volume Index m³	1.76 *(2.51)*	1.86 *(3.19)*	1.92 *(4.43)*	3.73 *(6.05)*	4.51 *(7.22)*	2.84 *(5.33)*	3.31 *(7.8*

Tab. 5.5: Structure parameters of shrubs (average), *(standard deviation of mean)*, drc = diameter at root collar

Just as the tree individuals do, the height and crown volume of the measured plants divide the watersheds into two groups: WS IV and V with the larger shrubs and I, II and III with the smaller ones. The number of trunks and the crown volume had the lowest values in WS I. WS III had the smallest shrubs with thin but numerous trunks. This was most probably due to the relative high ratio of *Acalypha fruticosa*, which has in general many thin trunks and is smaller in height.

In the thick vegetation of the Temple Forest the shrubs were on average taller than in the watersheds but they showed a smaller number of trunks and their volume was slightly above the watershed average but less than in WS IV and V. This indicates, together with the species composition, that shrubs would be present even if the forest is less or not influenced by humans.

5.1.4.4 Non-Individuals

Trees

Trees smaller than 50 cm had been defined as non-individuals and were therefor not measured intensively. Even if the definition includes older individuals that were kept small through grazing and cutting, can they be seen as the regenerating plants, because only 5 and 7% respectively showed signs of grazing and cutting.

They represent only 15% of all trees and with an average number per plot of 1.2 they occurred in almost 50% of all plots with only a little variation between the watersheds. The maximum number per plot was four. Their size varied between 0.03 and 0.50 meter with an average of 0.30 meter. However, the regenerating capacity was small.

34% and 23% of the regenerating species in the watersheds were *Commiphora berry* and *Euphorbia antiquorum*. The other species did not exceed 6%.

In the Temple Forest they occurred in 5 of the eight plots. The average was with 1.75 slightly higher than in the watersheds. A clear difference occurs among the main species, which were here *Azadirachta indica* and *Diospyros ebenum*.

Shrubs

Non-individuals among the shrubs are defined as plants with a diameter at root collar less than 1 cm. They represented 60 % of all shrubs and were therefor higher in number than the individuals. On average 2.7 of these puny shrubs were found in one plot of the watersheds while in Temple Forest they did not even reach half of this amount. Their height varied from 0.05 to 3.1 meters with an average of 0.6.
The species among them mostly represented the most among them was *Acalypha fruticosa* followed by *Jasminum trichotomum* and *Jasminum sessiliflorum*, *Coffea wightiana* and *Pterolobium hexapetalum*. This means a difference was found compared to the individuals, where *Flueggea leucopyrus* dominated. Except *Jasminum sessiliflorum*, which was represent in half of the plots, none of these species occurred in more than one plot in the Temple Forest.

Subshrubs

On average had the subshrubs a volume of 0.83 m^3 per plot. With 0.75 m and 0.93 m^3 the tallest and most voluminous biomass of subshrubs was found in WS III followed by WS IV and V. WS I and II contain the smallest plants and the lowest volume per plot for this phenotype.

Grasses

In the areas where *Themeda cymbaria* dominates, exists a dense grass layer out of thick culms. After fire, the soil surface is completely exposed until the next rain comes. Then the cover is re-established within days, depending on the amount of rainfall. The accumulation of grass biomass increases with decreasing fire frequency and creates vegetation that is difficult to access. Trees and shrubs can establish themselves best here if they are already present through rootstocks and therefore able to develop coppice. The other grass species do not create such a dense cover.
WS II showed with 0.57 and 0.95 m^3 the lowest height and volume of the grass layer because a fire broke out one month before the data where collected (table 3.4). WS V had clearly the most voluminous grass layer. On average the grasses here were almost a meter tall and a plot contained 2.47 m^3 grass volume. This watershed was affected by less frequent fires than WS I, II and III.
The two plots in the Temple Forest containing grasses had such a low fire frequency that the grass volume developed here to 3.4 m^3. The other plots had no grasses at all.

5.1.5 Damage

Trees

More than 40% of the tree individuals in the watersheds showed damage with the highest proportion in WS V. Among 38 tree individuals in the Temple Forest four showed a sign of damage. One was slightly burned and three were slightly cut

The ratio of browsing signs was the highest in WS IV while no tree in WS I showed any sign of grazing. But with 37% in this watershed the trees showed by far the most signs of cutting. Among the other watersheds the amount of traces of cutting was almost equal.

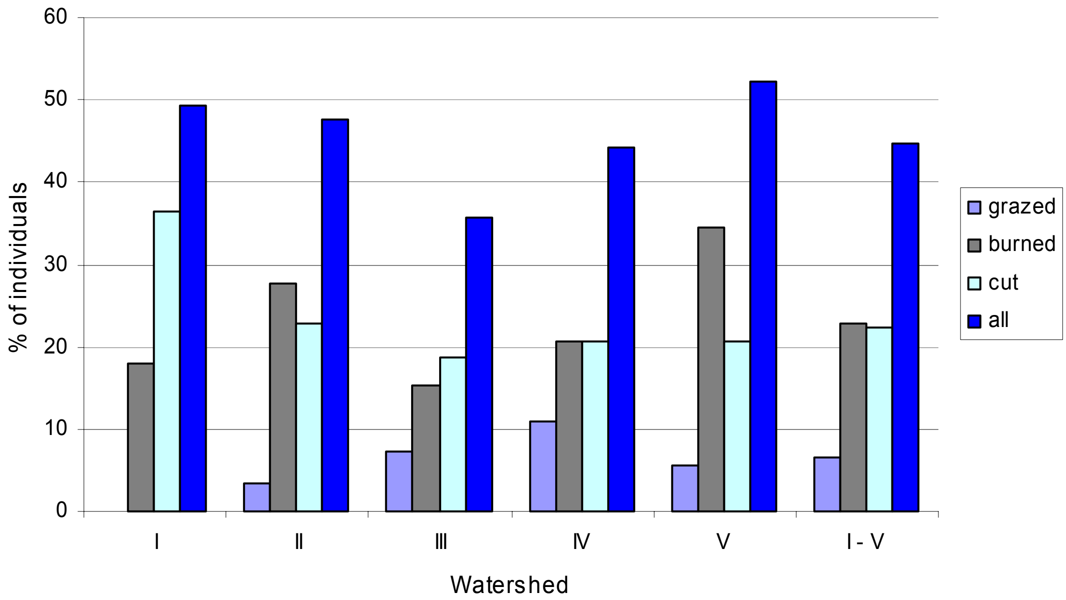


Fig. 5.4: Percentage of the different damage among the tree individuals in the watersheds

Trees which were visibly affected by fire showed the highest ratio in WS V and II. In WS II shortly before the data were collected, fire broke out and thus the signs here were fresh. But traces of fire can be observed for a considerable long time after the fire occurred. In WS IV, where no fire occurred during the study period, a fifth of the trees showed fire traces.

At different altitudes, the ratio of damaged trees increased at elevations above 400 meters. The distribution of different types of damage varied:
Signs of grazing could be seen mainly on trees below 300 m, which indicates a higher grazing pressure here. The ratio of trees with signs of cutting was almost equal among the watersheds. Only regarding the elevation a slightly higher ratio of traces was found below 300 and between 400 and 500 meters. The distribution of fire signs follows a clear pattern. It increases from under 10% below 300 m up to 45% above 500 m elevation. That means that cutting of wood dominates besides grazing on lower elevations while the main causes of damage higher up results from fires.

In the following the intensity of damage to trees from browsing and cutting respectively is described. The damage from fires is unspecific and depends on intensity and on time passed since the fire occurred.
The following two figures show the distribution of damage intensity among the injured individuals in the watersheds (see definitions table 4.5 and figure 4.6).

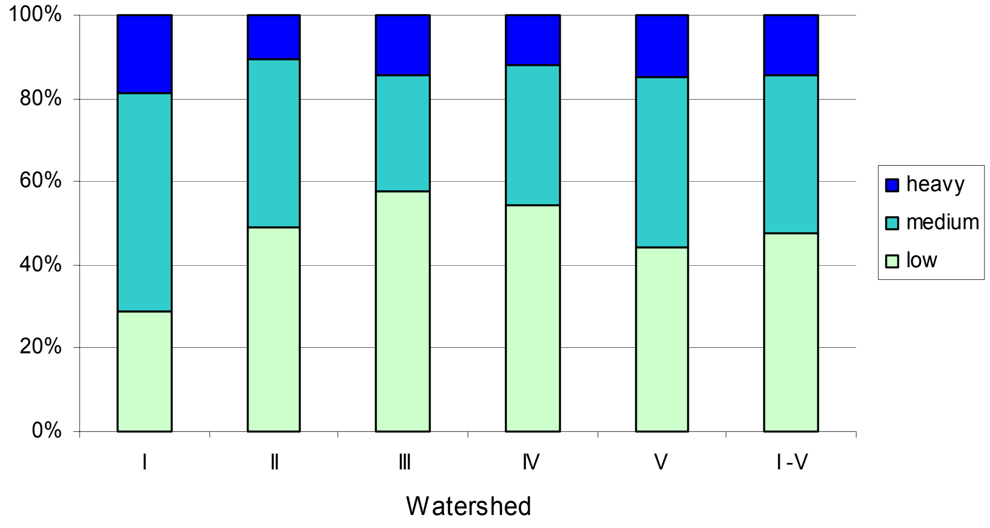


Fig.5.5: Cutting intensity among the damaged tree individuals in the watersheds

The individual watersheds differed clearly in their traces of cutting. More than 50% of the injured trees were deformed by chopping and 14% almost completely removed. The proportion of these two classes was the highest in WS I where 70% are cut intensively. WS V has the second highest ratio of these classes and WS III the lowest. Of the browsed trees, only 30% had changed their shape under the grazing pressure and only 5% were completely depressed. The frequency of heavily browsed trees is higher in WS III.

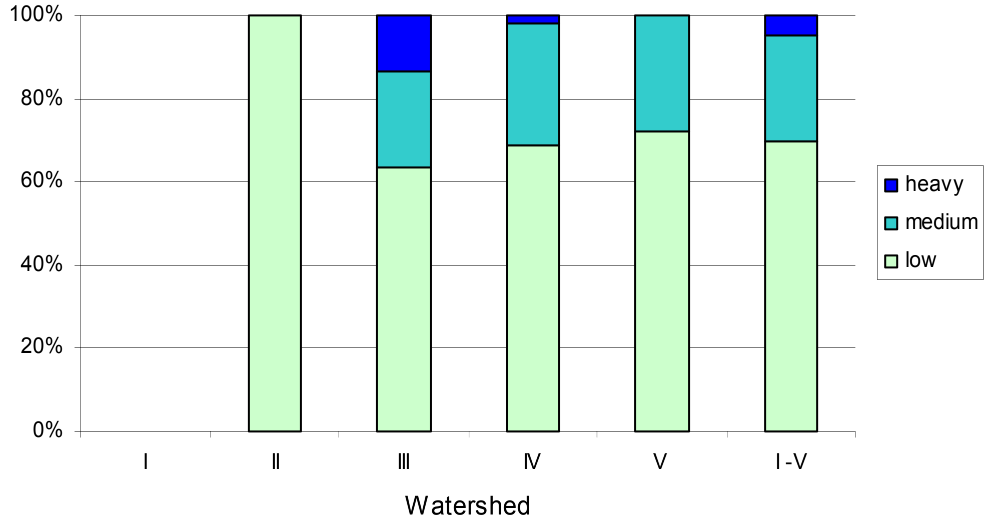


Fig.5.6: Browsing intensity among the damaged tree individuals in the watersheds

In the following, a view shall be taken on those species which were visibly affected by utilisation in order to conclude on the degree they are made use of.

Species	% of measured individuals	No. of injured individuals
Commiphora berryi	27	164
Acacia planifrons	50	52
Acacia horrida	38	21
Acacia spec. 1	35	16
Albizia amara	45	13
Diospyros ebenum	55	12
Euphorbia antiquorum	2	9
Acacia ferruginea	21	8
Dichrostachys cinerea	13	7
Pleiospermium alatum	44	7
Diospyros montana	50	6
Wrightia tinctoria	50	5
Canthium dicoccum	50	4
Commiphora caudata	23	3
Ochna obtusata var. gamblei	14	3
Azadirachta indica	33	2
Gyrocarpus americanus	25	2
Acacia chundra	14	1
Erythrina suberosa	20	1
Tarenna asiatica	8	1

Tab. 5.6: List of tree species showing signs of cutting in the watersheds (species represented with less than 5 ind. are omitted)

The most common and, as will be shown in chapter 5.2 most often mentioned species for fuelwood and small timber, *Commiphora berryi*, had the highest number of chopped trees but only 27% of all individuals had visible signs of cutting. Among the individuals of the second most often named tree species *Euphorbia antiquorum* almost no tree was harmed. The reason could be found in the growth structure of *Euphorbia antiquorum*, which allows the breaking of branches. If this is practised, signs of cutting are not visible.

Regarding the percentage of injured individuals, a different ranking among the species than reported by the users appears. *Diospyros ebenum*, the probably most valuable species in the Kadavakurichi forest, ranked first. It was followed by *Acacia planifrons*, *Diospyros montana*, *Wrightia tinctoria*, *Canthium dicoccum*, *Albizia amara*, *Pleiospermium alatum* and others.

Diospyros ebenum, *Diospyros montana*, *Canthium dicoccum* and *Albizia amara* were not mentioned by any user for any purpose. The intensity, in which the trees of this species in fact were used, gets underlined by the degree of damage. Figure 5.7 shows the ratios for the damage-classes for *Commiphora berryi* and *Acacia planifrons* and for the more preferred species defined here as higher than 40% injured individuals by cutting.

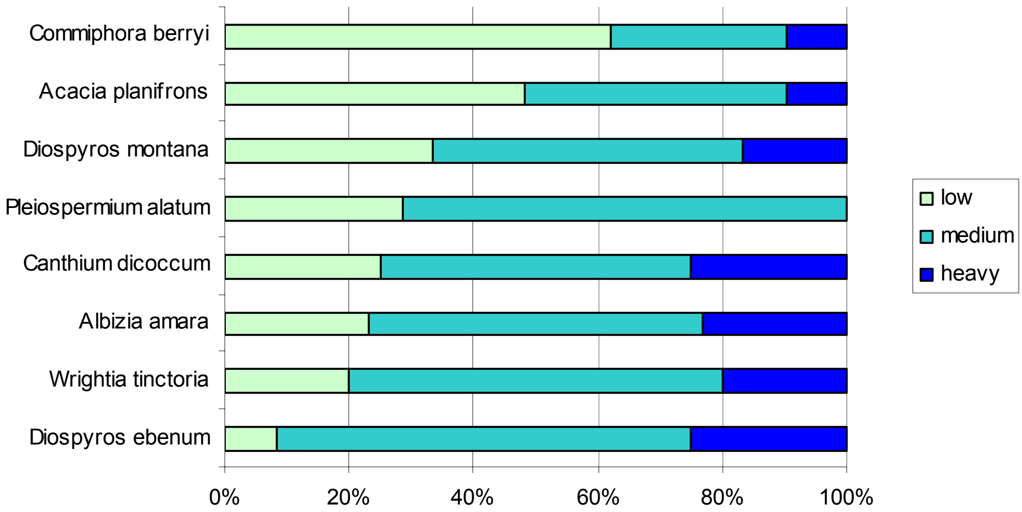


Fig.5.7: Damage of more than 40% of trees according to species.

Again *Diospyros ebenum* turns out to be a strongly used species. The measured individuals were mostly coppices of cut trees in a small part of thick vegetation at an altitude of 500 meter. Even the small dimensions of the cut wood (average diameter of the thickest trunk at the root collar was 3.8 cm) made it worth reaching this place to collect them. For fuel purposes the wood could have been collected in lower places just as well. It can be assumed that some people know about this species and maybe the places where they occur. The PHCC found in his survey 1992 (PHCC 1992) that a few people came especially for the collection of *Diospyros ebenum* to the hillock. *Wrightia tinctoria* also showed a high percentage of strongly damaged individuals. The relatively low impact of utilisation as green manure seems not to be the reason (see chapter 5.2.2.3). It is probable that the strongly injured individuals were used for fuelwood.
According to the grade the trees in the Temple Forest are cut, it can be assumed that wood collection did not happen there recently. But the trees in the plots showed a higher average of trunks than in the watersheds and can be assumed to be cut less frequently.

Regarding the browsed tree species, only 14% of individuals of the most important source of fodder among all trees, *Commiphora berryi*, showed signs of browsing (appendix 5.8). No tree species was browsed to more than 17% of all its individuals.

Shrubs

The rate of injured shrubs in the watersheds was lower than that of injured trees. 35% of all shrub individuals show at least one of the damage signs. WS I had the highest ratio followed by WS III.

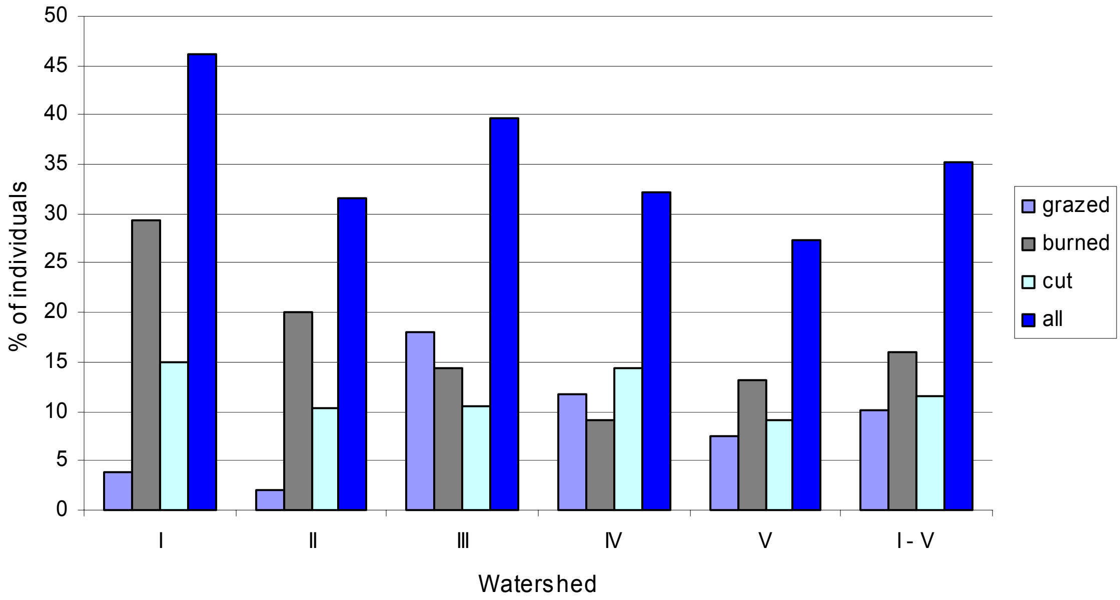


Fig. 5.8: Percentage of the different damage among the shrub individuals in the watersheds

The ratio of browsed shrubs was the highest in WS III with 18%, followed by IV and V. The distribution of fire signs mirrors the frequency of fires in the different watersheds. Both were higher in WS I to III while WS I had clearly the highest percentage. Signs of cutting were more frequent in WS I and IV. As it will be shown later, the former was the most and the latter the less intensively used. Thus, frequency seems not to be a good indicator for the intensity of use. The grade of damage is a better indicator as shown in the next figure.

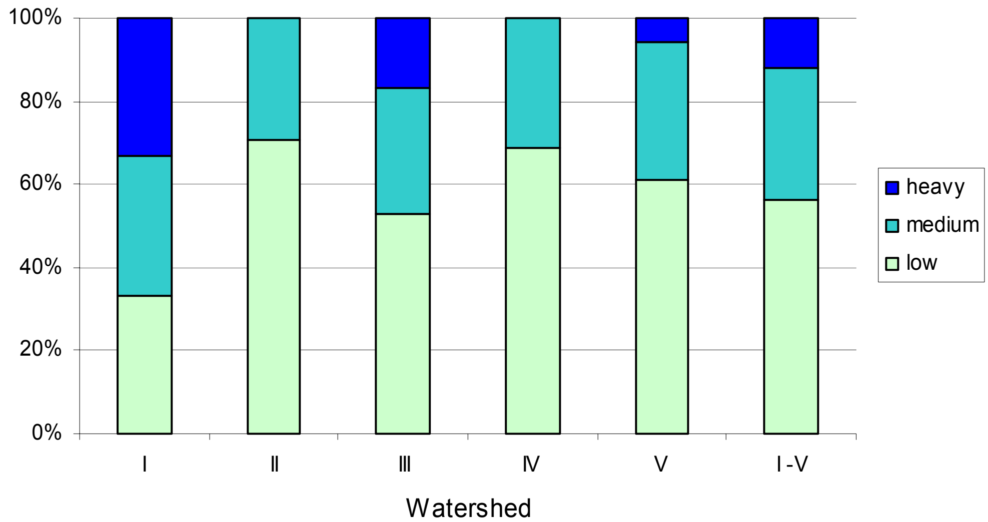


Fig.5.9: Cutting intensity among the damaged shrub individuals

As with the trees, the grade of the cutting-signs mirrors the intensity of wood collection in the different watersheds (see chapter 5.2.2).

The pattern regarding the elevation was as clear as for the trees. The grazing pressure was strongest at the bottom of the hillock. Fire damage was distributed in the same pattern as for the trees mainly on higher elevation. Cuttings signs are spread among all elevation belts with a slight decrease in upper parts.

Among the species, the most required species for fuel, *Flueggea leucopyrus*, showed the highest number of cut individuals. *Catunaregam dumetorum* followed. However among the total of all individuals of this species the ratio of injured plants did not exceed 20%. *Pterolobium hexapetalum*, which was named even more often than the other two species, showed cutting signs on only 4% of its individuals. Table 5.7 shows the shrub species with signs of cutting while species represented with less than 5 individuals were omitted.

Species	% of measured individuals	No. of injured individuals
Flueggea leucopyrus	19	33
Catunaregam dumetorum	16	29
Canthium coromandelicum	15	17
Grewia tenax	19	9
Pterolobium hexapetalum	4	7
Cassia auriculata	32	6
Carissa spinarum	18	6
Capparis sepiaria	9	5
Coffea wightiana	4	5
Erythroxylum monogynum	27	3
Grewia bracteata	20	3
Sarmenilla obsticifolia	14	2
Ziziphus oenoplia	12	2
Flacourtia indica	6	1
Jasminum trichotomum	2	1

Tab. 5.7: List of shrub species showing signs of cutting in the watersheds (species represented with less than 5 ind. are omitted)

The highest percentage of signs of cutting among the individuals of one species has *Cassia auriculata.* This species belongs to the family of the Fabaceae and accumulates nitrogen. It is a frequently named shrub used for green manure. Noticeable in this connection is the total absence of another green manure species in table 5.7: *Acalypha fruticosa* (see also appendix 5.2). This species grows with many thin branches from the bottom and it can be assumed that this makes it difficult to identify cuttings signs.

The greatest number of grazing signs and the highest ratio of browsed shrubs among the measured individuals had *Coffea wightiana*. It was obvious, that cattle preferred this plant although the cattle grazers never mentioned this species. The reason could be that it was unknown to them. The most often named species, *Flueggea leucopyrus* and *Acalypha fruticosa*, showed only a small percentage of browsed individuals with 4% each.

Subshrubs

In only 4% of all cases in the watersheds did the subshrubs show a sign of damage. Most were fire signs in WS II, III, and IV. Grazing and cutting signs were found only in two plots in WS III. The damage signs occurred almost solely on *Orthosiphon thymiflorus*. The few subshrubs in the Temple Forest didn't show any sign of damage

Grasses

In 12% of the plots in the watersheds containing grasses signs of damage were noted. Similar to the subshrubs, burning signs held the highest ratio with 7%. Signs of cutting were not observed. With 6%, WS IV held the highest ratio of grazing signs in all records followed by WS III with 2%. As will be shown in the next chapter were most of the sheep, the animals feeding mostly on grasses, grazed in WS III and IV.

Signs of	Watersheds					
	I	II	III	IV	V	total
Grazing	0	2	4	6	2	3
Burning	14	26	3	1	1	7

Tab. 5.8: Ratio of plots with signs of damage on grasses per watershed

Most of the grazing signs were at the bottom of the hillock and were negligible on elevations above 300 meters. The percentage of plots with burned grasses clearly increased with the elevation. While it was almost zero below 400 m it increased to a fifth of the plots above 600 m.
Fires that had occurred near the time of data collection made fire-signs dominant in WS II (26%) and WS I (14%).

The browsed species were mainly *Chrysopogon fulvus* (11 times) and *Themeda cymbaria* (5 times). The species that showed signs of fire most frequently was *Themeda cymbaria* (19 times) followed by *Chrysopogon fulvus* (8 times). This distribution seems to be a result of the species ecology. *Themeda cymbaria* was dominant on the regularly burned areas and *Chrysopogon fulvus* occurred where fires were less frequent. Therefore it was in the reach of the cattle on lower elevations.

5.1.6 Dead wood

The existence and dimension of dead wood can be assumed to mirror the intensity of fuelwood collection. This is borne out by the difference between the Temple Forest and the watersheds.

Plot cover in %	Watersheds						Temple Forest
	I	II	III	IV	V	total	
0	80	83	89	74	75	81	50
1-10	18	14	10	20	21	16	50
10-40	2	3	1	6	4	3	0
Average diameter (cm)	*1,59*	*1,67*	*1,63*	*1,77*	*1,70*	*1,70*	*4,6*

Tab. 5.9: Average diameter and percentage of plots with different cover of lying dead wood

No clear pattern between the watersheds can be observed. WS I, II and V are mainly used for fuelwood but show a different ratio of plots without lying dead wood. The pattern fits rather to the fire frequency in the different watersheds. WS I, II and III with more regular fires had fewer plots containing lying dead wood and if it were present, it covered a smaller area as in WS IV and V. However, the dimensions were in all cases small.
Standing dead wood was rather rare in the entire forest. Only 9% of all plots in the watersheds and one in the Temple Forest contained standing dead wood. The highest ratio showed WS II. The fire had been only recently here and the wood not removed at the time of data collection. The average diameter at root collar of the dead wood pieces in the watersheds was with 5.6 cm slightly under the average diameter of the living trees. They were around one meter tall while WS IV and V on average held the tallest pieces. In the Temple Forest, the standing dead wood occurred in the form of three dead climbers with a basal diameter of 1.28 cm and a average height of 2.7 meters.

5.1.7 Humus

The forest in the watersheds showed only a poorly developed humus layer. Only 16% of 500 plots showed a humus layer at all. Mull was the dominant humus form in the watersheds and Moder in the Temple Forest (table 5.10). “Mull” is characterised by a minimum or no accumulation of organic material above the mineral soil. It occurs on active soils with a high mineralization rate. The mineralised organic matter enters the mineral soil and builds up a horizon rich in humus (Ah). Thus an organic layer consisting mainly of “fresh” organic particles showing signs of mineralization (L and Of horizon) followed by a distinctive Ah-horizon. The humus form “Moder” indicates a slightly reduced mineralization rate and is characterised by an Oh-horizon consisting of full mineralised organic material directly on the mineral soil.

Humus form	Watersheds						Temple Forest
	I	II	III	IV	V	total	
non	88	91	87	81	78	84	0
Mull	12	9	12	16	16	14	1
Moder	0	0	1	3	6	2	90

Tab. 5.10: Percentage of plots showing a humus layer

The highest ratio of plots with organic matter on the ground was found in WS V and IV. The impact on organic matter was higher because of the denser tree cover here. In the Temple Forest all plots showed a much more developed humus layer.

The Mull of the Kadavakurichi followed this pattern in the layer of the organic material but not in the mineral soil, where an Ah-horizon was almost absent (table 5.11).

Humus layer	Humus layer not present		Thickness in cm							
			< 0,5		0,5-1		1,1-2		>2	
	W	TF	W	TF	W	TF	W	TF	W	TF
L	0	0	1	0	74	12	20	25	5	63
Of	54	0	31	50	15	12	0	12	0	36
Oh	89	12	11	76	0	12	0	0	0	0
Ah	99	76	1	0	0	12	0	0	0	12

Tab. 5.11: Ratio of different thickness of organic horizons among the plots showing a humus layer, W = watersheds, TF = Temple Forest

Table 5.11 shows that the humus layer was much better developed in the Temple Forest than in the watersheds. A higher ratio of plots had a thick L-layer and all plots showed an Of-layer which was in three out of the eight plots even thicker than 2 cm. Completely mineralised organic material was almost not present in the watersheds but in two out of eight plots in the Temple Forest.

5.1.8 Tracks

Footprints of human beings and domestic animals are hard to identify on the stony soil of the Kadavakurichi hillock. Visible signs are limited to regularly used paths and represent a high frequency of trampling. Such signs could be observed in 42% of the plots.
Table 5.12 shows the ratio of trampling within the watersheds and the Temple Forest.

Cover classes in %	Watershed						Temple forest
	I	II	III	IV	V	total	
0	76	63	59	50	55	58	100
1-20	24	29	31	30	39	31	0
>20	0	8	10	20	6	11	0

Tab. 5.12: Ratio of trampled plots within the watersheds

WS IV held the highest ratio of trampled plots with more than 20% followed by WS V and III.
The trampling signs had their highest ratio on lower elevations and decreased towards the upper parts of the hillock. Above 600 meters, trampling signs could again be observed more frequently. They occurred on this elevation mainly in WS I and V. This could be connected with the burned grasslands or with the honey collection activity, which was practised on the “honey rock” at the top of watershed V. However, even though it cannot be substantiate clearly it is visible that the watersheds were regularly frequented.

5.1.9 Dung

Only in 14 plots cattle dung could be observed. 5 plots contained cow dung, 7 plots goat/sheep dung and two plots both. The cow dung occurred in WS IV and III and half of it was found below 300 meters. The goat/sheep excrements were concentrated at the bottom of WS IV.
The number was too small to base conclusions on it. It only shows, that the grazing pressure of goats and sheep was relatively high in lower parts of WS IV and that cows entered the Reserved Forest in contrast to the results of the socio-economic survey (chapter 5.2).

5.2 Socio-economic survey

5.2.1 Socio-demographic data

This chapter shall focus on the socio-demographic characteristics of users and non-users. A detailed description of the way and intensity in which the different uses are practised is given in chapter 5.2.2.

5.2.1.1 Number and distribution of household

The affiliation of all households in the research area to the different strata is represented in table 5.13 (see also chapter 4.2.1). Almost 15% of all households in the study area utilised products from the Reserved Forest. The number of forest users where the highest in WS III followed by WS I and V. The smallest number of forest users was found in WS IV.

WS	Usergroups			Total users	Non-users	total No. of households	% users
	Fuelwood collectors	Cattle grazers	Others				
I	87	18	2	107	1008	1115	10
II	29	5	0	34	244	278	12
III	87	26	87	200	427	627	32
IV	13	6	0	19	479	498	4
V	56	13	0	69	338	407	17
total	272	68	89	429	2496	2925	15

Tab. 5.13: Number of households per watershed and usergroup

Firewood collection was clearly the most practised utilisation of the forest. It was concentrated on WS I, III and V. Herdsmen going into the RF for grazing their cattle were represented in all watershed while the users of other products are almost solely placed in WS III.

5.2.1.2 Size of households, building material of the houses and livestock

Size of households

The size of a household varied from 1 to 20 members with an average of 5 for both usergoups. User-households with a high or small number of members are less represented, but they show more households with 4-6 inhabitants than the non-users.
Among the watersheds only a slight difference can be seen. So have the watersheds which are inhabited by the greatest part of the users, WS I and III, the lowest average number of household member for users and the highest for non-users. And in the watershed, which was least involved in the forest utilisation, WS IV, it was the other way round. But the differences were too small to conclude a strong correlation.

House construction material

Most of the houses in the study area (80%) were made out of bricks. The ratio among users and non-users were equal. The reason why for the costliest material no difference existed could be that bricks are used in housing-programs of the government and are therefor available for a reasonable number of poorer households. A difference could be observed among the other materials. Non-users' houses where more often made out of stones while users more often used the cheapest options: clay and light material. None of the studied houses in WS IV and V were made out of these materials, but in WS I and III 13% and 10% of the households respectively; whereas in WS I the ratio of houses out of light material was the highest with 11% (see also chapter 3.4.3).
Concerning the material used for the roof construction, the difference between user and non-user households was also not much. But it could be clearly seen, that the non-users were living to a greater part in houses with more expensive roofs than the users, of whom only a few have concrete roofs but a higher ratio use asbestos, coconut leaves and grasses. The distribution of roof types was almost equal among the different watersheds.

In general it can be said that material, which does not have to be collected from natural sources dominates in house construction. This indicates a relatively low relation between the materials used for house construction and the nearby natural environment.

Livestock

More than half of all households did not have any livestock. The average number of livestock that households kept was 5.6 heads, with goats and cows being the mainly reared animals. The ratio of households keeping livestock among the users was slightly lower than among non-users. Among the user households, goats and sheep were found more often and in greater numbers than with the non-users. In contrast, the latter showed a higher rate of cows, though in low numbers (appendix 5.5, table 1). Bullocks showed an equal distribution among users and non-users, while Dung Cattle (Kadaimadu) was restricted to user households and except in one case, where there were herds of 12-18 heads. This distribution already indicates the use of the forest for grazing. The users keep mainly cattle that can easily be grazed in the forest. The necessity of milking it twice a day makes the cow a less suitable animal for keeping away from the house. Kadaimadu is an exception. This animals are not milk animals but used for fertilisation. They are grazed on fields after the harvest and during the agricultural season in the forest.
Regarding the distribution in the different watersheds, it is striking that among non-users the highest ratio of goats was found in WS IV and V whereas sheep were predominant in WS IV. Households in these two watersheds have access to the taluk forest. The households grazing their animals only there had not been classified as users, which means that herdsmen were included here who had no contact with the Reserved Forest. In WS IV and V with 40% and 29% respectively, a relatively low percentage of user households without cattle were counted, compared to the other watersheds where 64 % on average were without livestock.

5.2.1.3 Castes

The surveyed households in the entire study area belong to 19 castes. The non-user households accounted for 18 of them, while the user households only for 10.

Among the user households only two castes were represented with more than 10%. These were the Moopar and the Nayakkar, of which the Moopar amounted to 54% alone. Thus this is the caste, which was most involved in the forest utilisation (figure 5.10).

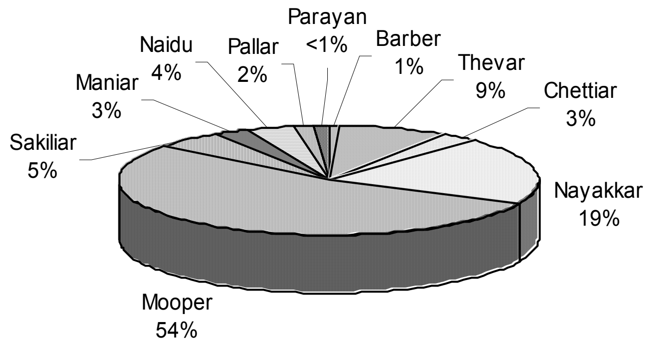


Fig. 5.10: Cast-structure of user households and their ratio

The dominance of the Moopar in the utilisation of the forest is valid for all products except for he collection of green manure (see also appendix 5.6, table 1).

In contrast to the cast composition among the forest users the non-users showed a clearly different caste-structure. With Thevar (20%), Moopar (19%) and Nayakkar (11%) the three casts holding the highest ratio in the entire study area (see appendix 3.1) dominated here. All others were below 10% (figure 5.11).

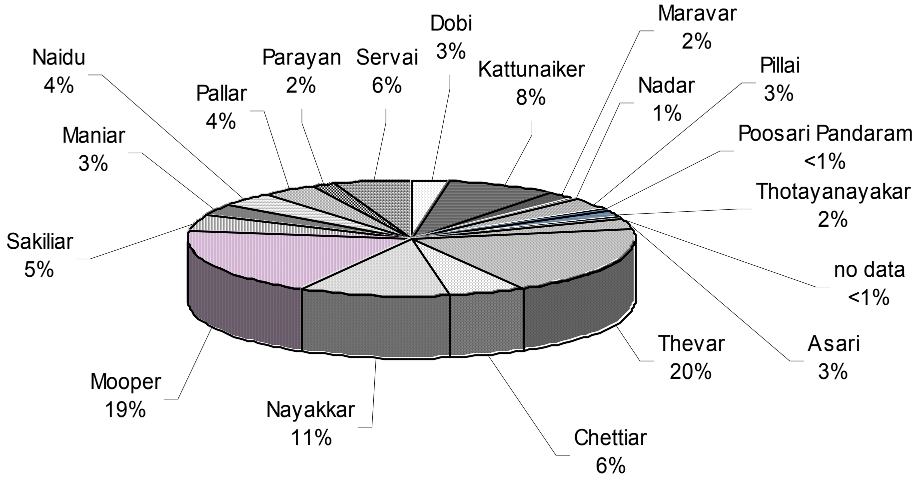


Fig. 5.11: Cast-structure of non-user households and their ratio

In the census of the PHCC 1996 for the entire area the Moopar were the most numerous caste with 23%. Moopar occurred only in WS I and III. In WS I they are present in seven of eight villages, whereas half the households of Veelinayakenpatty and 80% of Kamatchipuram belonged to this caste. In WS III all Moopar households are located in Kombaipatty (PHCC census 1996). Kamatchipuram and Kombaipatty are related villages. It is usual that marriages are arranged between families of both villages.

5.2.1.4 Age and Gender

Age

The difference in the age distribution between non-users and users was only small. Among the users were also children. They were mainly collectors of medicinal plants from Kombaipatty (WS III) and also involved in fuelwood collection and grazing.
The non-users had a higher ratio of people in the age group between 41 and 50 than the users but a lower one in the age group between 51-60. The high ratio of users in this age group shows that relatively many older people had to partake in the forest utilisation work. The proportion of users above 60 years was relatively low in contrast to the percentage of this age group among the non–users. It seems that people of this age were not involved in the utilisation of the forest any more.

Gender

The gender distribution varies among the strata. Men were to a greater part involved in fuelwood collection while women were represented with a higher number in the stratum “others”. They were dominant in the green manure collection.

	Male	Female	Sum
Users	**150**	**72**	**222**
Fuelwood collectors	105	35	
Cattle grazers	25	12	
Others	20	25	
Non-user	**123**	**128**	**251**

Tab. 5.14: Distribution of gender among the strata

The relationship between the genders did not change much, when the not questioned members of the households who were involved in using forest products, were also taken into account (see appendix 5.6, table 3).
The non-users showed an almost equal distribution among the genders.

5.2.1.5 Employment

In order to investigate whether the questioned persons earn income, they were asked about their occupation. Some of the people questioned had two. The most common combination was farmer and day-labourer or persons, who named their work in the forest as their main job and who were in addition day-labourer. The occupation, which was described by the questioned person as the more important one, was set as the main job. Figure 5.12 shows

the different professions and their proportion among the users and non-users. Appendix 5.5 table 2 and 3 gives their distribution to the different watersheds.
Coolie means here day labourers. These persons work in different fields for daily wages. Those people who cultivated their own land were called "farmer" so not to mix them with landless agricultural labour. Six farmers had leased their land to others. Small-scale traders are persons, who had a small business on their own. Very often they sell small things required in the household, plastic toys or food. As housewife were classified women above 19 years old who didn't name any other profession.

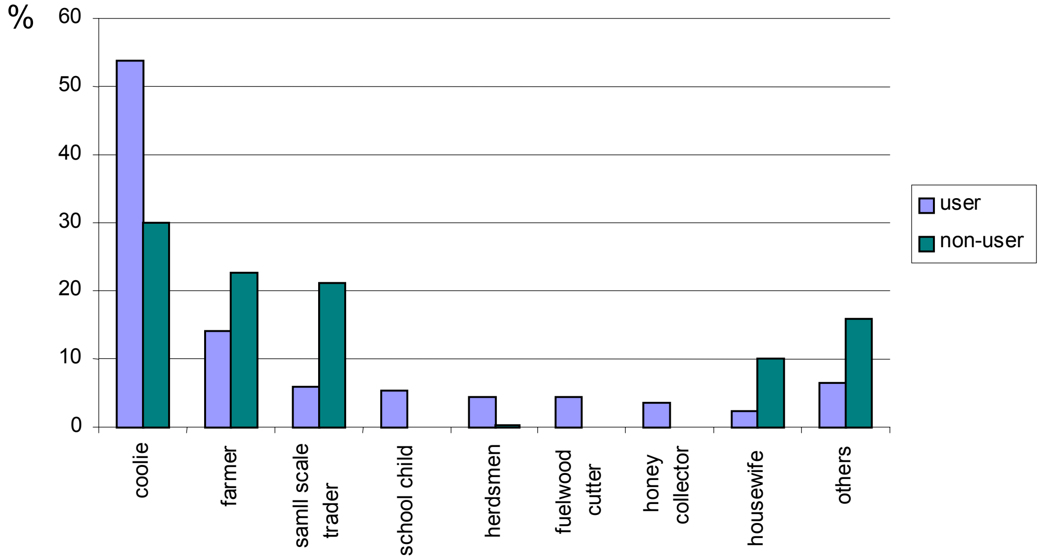


Fig.: 5.12: Distribution of the main profession

The clearly dominant occupation among all questioned persons was coolie. More than half of the users and one third of the non-users called themselves coolies. They had the highest portion in WS III while they were distributed almost equally over the other watersheds. The second most important occupation for both groups was farmer, where the proportion of the non-users was higher than of users. Only 7% and 4% of the users in WS I and III respectively are farmers, while the proportion among the other watersheds varies between 30 and 39%. Also among the non-users farmers were less represented in WS I and III, but their proportion was higher than among the users, in WS III even six times.
Small-scale trader was the third most important profession in both groups. It represented a fifth of the non-users and 6% of the users. Among the users traders took the highest portion in WS I and II while they showed almost the same ratio among the non-users over all watersheds.
Another striking fact illustrated by figure 5.12 is the high difference in the ratio of housewives. This could be caused by gender distribution among the interviewed non-users. But it also shows that relatively few women among the users were engaged only in housework. The same held for retired persons, who did not exist among the users. The

astrologers belong only to one village, Pudupatty in WS I, where 15 out of 27 questioned people are engaged in this profession[1].

Table 5.15 shows the number of people who had no job at the day of the interview. Housewives, who can not be employed in the sense of raising an income for the household, were not considered here.

	Users	Non users
Employed with two jobs	5 (2%)	8 (4%)
Employed with one job	105 (49%)	170 (75%)
Unemployed	107 (49%)	48 (21%)
Sum	217 (100%)	225 (100%)

Tab. 5.15: Unemployment rate among users and non users

The unemployment rate among the questioned people was high. It differs greatly between users and non-users. While almost half of the forest users were not employed in any job at the time of the questionnaire, "only" a fifth of the non-users had no employment. This ratio gets even bigger if the income from the forest is excluded. In this case 62% of the users did not have any income besides that from the forest.
The distribution of unemployment (no income except from forest) among the watersheds is given in figure 5.13.

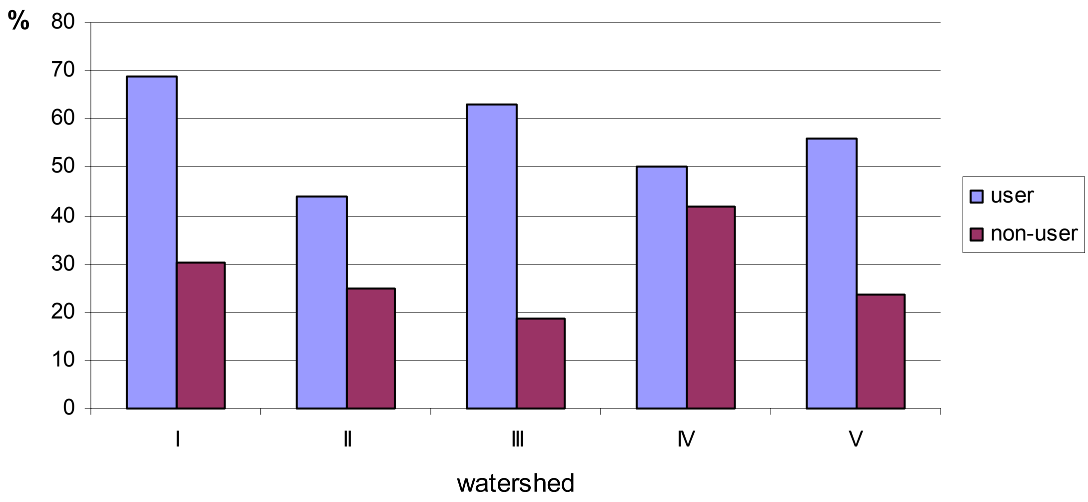


Fig. 5.13: Percentage of unemployed questioned persons

[1] All of them belong to the caste of the Kattu Nayakkar. This caste does only occur in this village (PHCC census 1996).

The highest unemployment rate among the users was found in WS I where 70% were without income from outside the forest, followed by 63% in WS III and 56% in WS V. The distribution of the non-users was different. WS IV showed the highest unemployment rate, most probably caused by the small number of persons questioned. WS III had the smallest rate of unemployed people among the non-users. This makes WS III the watershed with the greatest difference between the ratio of unemployed people among users and non-users. This big difference in all intensively used watersheds (I, III, and V) leads to the assumption, that employment factor plays an important role in a determining the utilisation of forest resources.

5.2.1.6 Ownership of land and use of this land for tree planting

In order to investigate if and with what intensity the households use their own land for growing trees and forest products, and what makes them or keeps them from doing so, questions relating to the ownership of land and the motivation for tree planting were asked. About half of all households owned land. Among the users, the households in WS IV and V were with 90 and 76% respectively clearly above the average.

Table 5.16 shows the main use of the trees planted and the frequency of their being mentioned. The classification of trees according to a main use was done mainly on information from PHCC and the experience of the author. A detailed list on the single tree species is given in appendix 5.7.

Main use of tree species	% of the mentioned tree species	
	Users	Non-users
Timber	46	32
Fruit	35	49
Medicinal	17	16
Fodder	1	1
Fuelwood	1	1
Green manure	0	1

Tab. 5.16: Percentage of mentioned tree species according to their main use

The main emphasis on tree planting was different for users and non-users. The most frequently planted trees by users were timber trees followed by fruit trees while, for the non-users it was the other way round. The timber trees are planted along irrigated fields and harvested very early (after 3 to 6 years) to be used or sold as small timber while the fruit trees are planted in fields or separately. The species used were almost the same among users and non-users.

The priority for cultivating the own land was not to substitute forest products. Tree species which can be used for green manure or which give mainly firewood did almost not exist among the planted trees. These species do not demand irrigation if a slow growth is accepted, while most of the species, which are used by the households, in general do need artificial watering.

Most people mentioned the generation of income as a reason for planting trees[2]. It was mentioned, as the sole reason or among others, by 50% of non-users and 40% of the users. Support through third parties was for the users another very important motivation. Here the PHCC and the forest department as providers of free or cheap seedlings were named. The wide gap between the number of users and non-users who gave this answer may be the result of subsidy by the PHCC and the forest department for the households depending on the forest. The use of the products gained in their own household was given by 17% of the users as the reason for cultivating trees, which is therefore the third most important motivation. For the non-users this was the second most important reason, named by 33% of the questioned persons.

As was shown above, the major part of the planted trees depended on irrigation. No access to water keeps people therefore from cultivating trees. Both, non-users and users, mentioned this as a main reason for not planting trees.

The second most important reason, among users and non-users in almost the same proportion, was the priority given to agricultural crops. They provide a faster return of the investment even on dry land.

Thus it can be stated that trees are chosen as a form of land use if irrigation can be applied or, if the landholder sees a chance of benefiting (financially or from the a natural product) and if tree planting is subsidised. The interest here was concentrated on fruit and timber as products and only for a very limited proportion on the substitution of the utilised forest products.

[2] The answers to the question regarding the reasoning behind planting trees were sorted in clusters according to their similarity. These clusters and the number of answers are given in appendix 5.5 table 4 and 5.

5.2.2 Forest uses

The forest users were asked about the products they use from the forest. Each questioned person named one or more products. This chapter describes the patterns in the use of these different products without distinguishing between the defined user strata. The number of named products for the different strata is given in table 5.13. Table 5.17 shows the distribution of the named forest products per watershed.

Product / use	Watersheds					Total	% of users
	I	II	III	IV	V		
Fuelwood	49	14	53	7	21	144	66
Grazing	6	4	13	4	6	33	15
Green manure	1	1	19	1	2	24	11
Honey	4	1	13	0	0	18	8
Medicinal plants	0	0	13	0	0	13	6
Fence material	0	0	8	1	0	9	4
Thatching	1	0	7	0	1	9	4
Small timber	1	0	4	0	0	5	2
Hunting	1	0	1	0	0	2	1
Roots	1	0	0	0	0	1	0
Total number of user	55	18	105	10	34	222	

Tab.5.17: The number of named uses

Fuelwood was the most often named forest product. 66% of all users entered the hillock to collect fuelwood. Most of the fuelwood collectors entered the forest from WS I and III, while WS IV was clearly the one with the smallest amount of fuelwood cutters.
15% of the user-households used the forest for grazing. Also here WS III followed by I and V contained most of the cattle grazers. In WS IV, 4 out of 10 interviewed users went to the forest for grazing, which makes this the highest percentage among the watersheds. The use of green manure, honey, medicinal plants, material for fencing and thatching and small timber were mainly concentrated on WS III.

The users were asked to rank the forest products according to their importance. In no case more than three products were mentioned, which results in three degrees of importance. Table 5.18 gives the rank of importance for the different users watershed-wise.

Use / product	Importance rank	Watersheds					Total
		I	II	III	IV	V	
Fuelwood	1	47	12	44	6	19	128
	2	2	2	9	1	2	16
Grazing	1	5	4	13	4	6	32
	3	1	0	0	0	0	1
Green manure	1	0	0	19	0	1	20
	2	1	1	0	1	1	4
Honey	1	1	0	12	0	0	13
	2	3	1	1	0	0	5
Medicinal plants	1	0	0	8	0	0	8
	2	0	0	4	0	0	4
	3	0	0	1	0	0	1
Fence material	2	0	0	4	1	0	5
	3	0	0	4	0	0	4
Thatching	1	0	0	1	0	0	1
	2	1	0	5	0	0	6
	3	0	0	1	0	1	2
Small timber	2	1	0	3	0	0	4
	3	0	0	1	0	0	1
Hunting	1	1	0	1	0	0	2
Roots	3	1	0	0	0	0	1

Tab. 5.18: Importance of forest products

Fuelwood and grazing were mainly named as the most important use of the forest. The same ranking was made for green manure while construction material (fence, thatching and small timber) were relatively seldom more important than other products.

In the following the utilisation pattern for each product is described. First a short compilation of the socio-demographic characteristics of the households using the product is given, followed by data about the use itself. The socio-demographic data grouped according to the named use is given in appendix 5.6.

As shown above (chapters 2.2.4 and 3.9) fire is an important form of land management in India and in the study area. The pattern of this “forest use” can not be described like the other forest uses, because it was not possible to point out the group of persons who are setting the fires. Beside the answers regarding the causes of the forest fires (chapter 5.2.3.1) for each product the connection with the fire effect on the vegetation shall be looked at.

5.2.2.1 Fuelwood

Fuelwood was used for cooking in the study area. Warm meals are required three times a day. Almost 60% of the households using fuelwood from the hillock belong to the Moopar caste. Most of the fuelwood collectors are between 19 and 60 years old with a dominance of the age group of 19-30 years. Two thirds were of male gender (appendix 5.6, table 1-3).

Season, frequency and locality of use

Fuelwood was collected throughout the year. Only a few people concentrated their fuelwood collection on a special season. However, summer was preferred more or less (table 5.19). Summer is the time when the forest fires usually occur. This allows the "harvesting" of dead wood.

Season	Watersheds					
	I	II	III	IV	V	I-V
Summer	4	0	3	0	2	9
Winter	2	2	0	0	0	4
Whole year	34	12	47	7	18	117
No use at present	6	0	3	0	1	10
No answer	3	0	0	0	0	3

Tab. 5.19: Number of people stating the seasons for fuelwood collection

Within the season which was preferred for collecting fuelwood, most of the users go weekly or at least more often than once a month (table 5.20).

Frequency	Watersheds					
	I	II	III	IV	V	total
Daily	10	-	6	-	-	6
More than once a week	12	14	6	-	14	10
Weekly	22	14	26	29	24	24
More than once a month	14	50	25	14	29	24
Monthly	12	-	23	29	19	17
Less than monthly	12	7	8	29	10	10
Not in the last five years	4	-	2	-	-	2
At present no use	12	-	6	-	5	7
No answer	-	14	-	-	-	1

Tab. 5.20: Frequency of entering the forest for fuelwood collection in %

A higher percentage of the fuelwood collectors of WS I, III and V went weekly or more often as in the other watersheds, while a daily access of the RF for fuelwood collection occurred only in WS I and III. WS IV showed the lowest frequency.
To get an impression of the intensity in which the different watersheds are used for fuelwood collection, the places on the hillock in which fuelwood was collected, were investigated. Table 5.21 gives the number of fuelwood collectors by the watersheds they live in as well as the ones accessing the RF of each watershed.

User in WS	No of users	Collection in RF of WS						No answer
		I	II	III	IV	V	Entire hillock	
I	49	31	-	7	1	28	-	2
II	14	-	14	2	-	-	-	-
III	53	1	1	48	7	-	-	-
IV	7	1	-	-	6	-	-	-
V	21	2	-	-	-	21	-	-
sum	144	35	15	57	14	50	0	2

Tab.5.21: Fuelwood used from and in the watersheds

In all watersheds most of the people collected fuelwood in the RF of their own watershed. But some did also access other parts of the hillock for that purpose. The people who used other watersheds intensively were the fuelwood collectors from WS I. More than half of them collected in the neighbouring WS V but only 2 of 21 fuelwood collectors of WS V used WS I for collection. WS III contained the highest amount of fuelwood cutters who nearly all collect their wood from this watershed. This and the fuelwood collectors from WS I and II made the forest of WS III the most frequented watershed for fuel followed by WS V. The RF in WS I ranked in third place in the intensity of fuelwood collection, but, according to the number of wood collectors it contained, it was relatively less frequented. WS II and WS IV were almost equally seldom used.

Most of the questioned fuelwood cutters (except the one in WS IV) said that they use all areas of the forest of the watershed. If areas were named, they laid mainly in the lower parts of the watersheds.

Used species, plant parts and amount

Overall 19 tree species, 15 shrub species, one subshrub and three herbal species are used as fuel (appendix 5.8).

Asked, which species had the highest importance in fuelwood collection, 102 of 144 fuelwood cutters mentioned *Commiphora berryi* while *Euphorbia antiquorum* takes the second place with 20 referrals. The ranking in importance for *Commiphora berryi* and *Euphorbia antiquorum* was almost equivalent to the frequency of naming among the different watersheds. In WS I, III and V *Commiphora berryi* was for most of the users the most important fuelwood species, while *Euphorbia antiquorum* has for an equal and higher number of users the highest importance in WS II and IV respectively. *Acacia planifrons* was only in WS I, II and III named as a most important plant. The tree individuals of these three species did not show a difference in their growth from the average of all species, which seems obvious as they represented the major part of the trees in the forest (appendix 5.3, table 1 and 5.4, table 2).

Among the shrubs the most often named species were *Pterolobium hexapetalum*, *Catunaregam dumetorum* and *Flueggea leucopyrus*. The frequency of this species in the forest was different. Here *Flueggea leucopyrus* occurred most often while *Pterolobium hexapetalum* takes the third and *Catunaregam dumetorum* the seventh rank (see appendix 5.3, table 1). Among the watersheds were mainly *Pterolobium hexapetalum* and *Flueggea leucopyrus* used in all watersheds except WS II. In WS IV the use of shrubs as fuel was very limited.

It is not only the incidence of the used species, which describes the utilisation pattern of fuelwood but also the intensity with which the plants get cut and the amount of the cut wood.

In table 5.22 the use of plant parts of trees and shrubs is combined with the naming of the frequented watershed. The frequency of naming the single plant parts here is therefore higher than that of the species.

WS	Type	Branches	Leaves	Whole plant	Whole plant above the ground	Bark	Dead parts	Total
I	Shrub	3	-	-	4	-	10	17
	Tree	10	-	3	14	-	54	81
II	Shrub	4	-	2	8	-	3	17
	Tree	10	-	-	7	1	10	28
III	Shrub	21	-	1	8	-	22	52
	Tree	62	3	2	6	-	50	123
IV	Shrub	4	-	-	0	-	5	9
	Tree	4	-	-	1	-	21	26
V	Shrub	5	-	1	4	-	10	20
	Tree	21	-	3	15	-	72	111
No answer	Tree	-	-	-	-	-	3	3
Sum		144	3	12	67	1	260	487

Tab.5.22: Used plant parts of trees and shrubs for fuel in the RF of the different watersheds

The forest department allows the use of dead wood (see chapter 3.7). Even with the very low presence of dead wood observed on the hillock, which also showed an insufficient dimension for a satisfactory fuel yield (see chapter 5.1.6), the most often named plant part was "dead parts". Dead parts were used after a fire event, which kills the whole or at least parts of the woody plants that can then be used legally. But not only the users, who prefer the watersheds with a higher fire frequency (WS I, II and III), said they use dead plants parts. The proportion of naming dead wood was also high in the other watersheds. It seems that this answer was given to avoid potential punishment because of illegal forest use.

In addition, "branches" was named for most shrub and tree species. The third most often used practice was to cut the complete plant or remove it, in a few cases, including roots. This was mainly done in the forest of WS I and V on trees. In the forests of WS II and III it was also common but here shrubs are more stressed. As table 5.23 shows, the users who were practising this method on trees were located in WS I, II and III with an emphasis on WS I.

WS	Trees	Shrubs
I	6	2
II	4	5
III	4	3
IV	0	0
V	0	1

Tab.,5.23: Number of persons using the whole plant fuel

It is striking that in the watersheds where the users of whole plants are living, fires occur more regularly (see table 3.4). Presumably a connection between the use of fire and the use of fuelwood exists.
Regarding the amount of the used fuelwood per entry in the forest, only the statements of the users are available.

n	126
Average	33
Standard Devi.	14
Don't know	18

Tab.5.24: Collected amount of fuelwood per visit to the forest in kg

If fuelwood is sold, it is sold by weight. Therefore the collected amount of fuelwood reported by the fuelwood-sellers should be a good proof of the data in table 5.20. Here the average was smaller than the one given by the fuelwood-sellers, which was 38 kg.
Doing the calculations with the parameters of table 4.8 gives an annual used amount of 238 kg fuelwood per ha in the entire forest. Figure 5.14 shows the annual quantity in kg per ha and watershed.

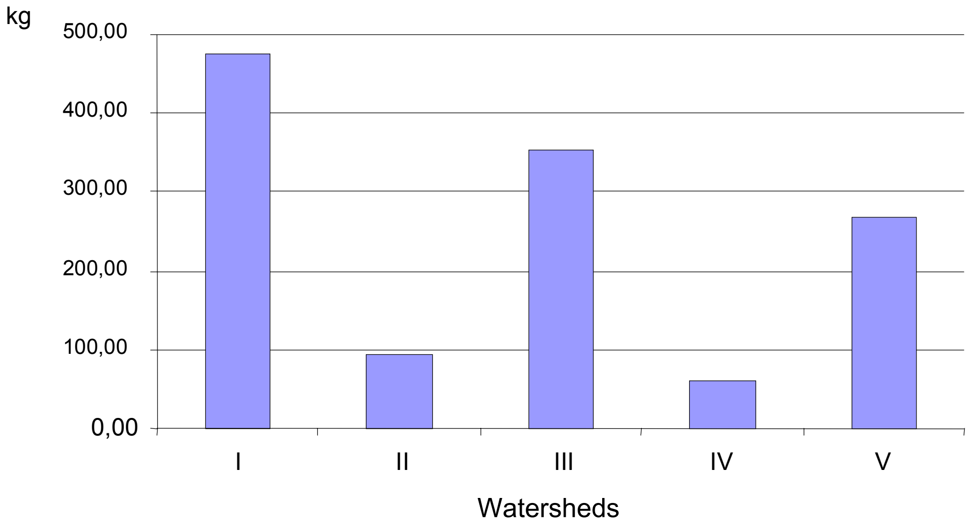


Fig. 5.14: Amount of fuelwood collected in the watersheds in kg/ha

The highest amount of fuelwood utilised by the questioned persons was with almost 500 kg/ha taken from the forest of WS I followed by WS III and V.

Of all forest users which could be identified, 50% were interviewed. For the total number of users it can be estimated, that the Kadavakurichi RF provides an amount of 470 kg fuelwood per ha annually. In WS I this sums up to a ton per ha and year, in WS III 700 kg and WS V more than 500 kg.

Purpose of collection and shortage

Almost all of the fuelwood collectors used the wood in their own households. In the entire study area only a good fourth did sell it, too (table 5.25).

WS	No. of users	Own consumption	Sale	
			n	%
I	49	48	22	45
II	14	14	3	21
III	53	53	12	23
IV	7	7	0	0
V	21	21	0	0
total	144	143	37	26

Tab.5.25: Purpose of collection of fuelwood

Comparing the different watersheds, two things can be seen. One is that the percentage of users who sell the collected fuelwood was extremely high in WS I. Almost half of those fuelwood cutters did sell. The second thing is that the selling of fuelwood did only occur in the watersheds where whole trees and shrubs were also removed and where fires occurred regularly.

It is obvious, that fuelwood was the main product utilised in the forest. The times when the need of the people was satisfied or when the demand was greater than the production of fuel is shown in the next table.

WS	No shortage		Shortage								Sum
			Whole year		Summer		Winter		Total		
	n	%	n	%	n	%	n	%	n	%	n
I	35	71	8	16	1	2	5	10	14	29	49
II	10	71	3	21	-	-	1	7	4	29	14
III	45	85	3	6	1	2	4	8	8	15	53
IV	7	100	-	-	-	-	-	-	-	-	7
V	17	81	4	19	-	-	-	-	4	19	21
total	114	79	18	13	2	1	10	7	30	21	144

Tab.5.26: Shortage of fuelwood in the different seasons

It was not expected that in total only 21% of the fuelwood cutters said they would not find enough fuelwood in the forest. In WS I and II almost a third were not satisfied with the fuelwood supply of the forest and do therefore both rank on the fist place. In WS III, which is inhabited by the highest number of fuelwood cutters and of which a good fourth did sell fuelwood from the forest and who mainly collect in there own watershed, only 15% did not find enough fuelwood.

Most of the collectors felt the shortage throughout the year. But when a season was named, it was winter. In summer the supply of fuelwood is higher because forest fires occur more frequently.

Other sources and ideas for improvement

As a last point it shall be investigated, if other sources than the RF exist for fuel (table 5.27) and if the users can see ways to improve the supply.

WS	No other source		Agricultural land	Coconut fields	Tank	Brooke side	Prosopis fields	Purchase of fuelwood	Talluk forest	Kerosene stove	Road side	Wasteland	Others
	n	%											
I	26	53	5	4	1	4	3	1	4	2	2	1	1
II	8	57	1	5	-	-	1	-	-	-	-	-	-
III	29	55	8	4	9	-	1	2	-	-	-	-	1
IV	1	14	5	-	1	2	-	-	-	-	-	-	-
V	13	62	7	-	-	-	-	1	-	-	-	1	-
Sum	77	53	26	13	11	6	5	4	4	2	2	2	2

Tab.5.27: Alternatives to the RF for fuelwood collection

More than the half of all people using the RF for firewood did not have an alternative source to satisfy their need for fuel. The ratio was the highest in WS V, almost equal in WS I, II and III and the lowest in WS IV. If fuel was also collected elsewhere, it was mainly on agricultural land or in coconut plantations. The tank in WS III was an important source for the people there. Other sources in the form of forest or forest-like plantations were rare. Only 5 people collected in *Prosopis*-fields (areas where *Prosopis juliflora* grows wild or at least unmanaged) and 4 in forestlands belonging to the talluk. These people were, against expectations, not in WS IV or V where talluk forest exists. Sources which are not organic material were hardly named. Only two persons gave kerosene as an alternative to fuelwood.

In order to get to know which possibilities the people see to improve the supply, they were asked about their ideas for obtaining more of the product used.

64 of 144 people questioned using fuelwood from the RF recommended the planting of trees as a possibility to get more fuelwood. If a location was given, it was mainly the hillock. Only two said they could plant trees on their own land. Two persons added to their statement that these plantations should be protected.

Only 4 people recommended a different habit for the collection itself. This included statements about the use of different areas where more fuelwood is available, the permission to cut also living plants and the concentration on dead wood or on certain species only, which had not been planted. A connection between fuelwood and fire could be taken from eight answers. 4 people said that they need dead parts of trees, two said that they get more fuelwood after a fire and two said that they can get more fuel in summer, which is the time of the forest fires. Only three persons see a possible way in purchasing fuel.

All together 56 people did not make any suggestions. 33 said they don't know, 13 didn't see a possibility to improve the supply of fuel and 10 did not see a need to do so.

5.2.2.2 Grazing

In total 15% of the questioned forest users said they'd enter the forest for grazing. Almost 40% of them were located in WS III and 20% in WS I and V respectively. Grazing ranked, except in one instance, always in first place of importance (table 5.18).
Almost half of the herdsmen belong to the Moopar caste, 33% are Nayakkar and 12% are Thevar. The ages of persons questioned were from below 14 to above 60, while most of them were between 19 and 50. Among all people in the studied households involved in grazing, most were of male gender. Women and children took part in grazing to 25%.

Season, frequency and locality of use

Grazing was done throughout the year while some of the herdsmen preferred the winter, in which the forest is richer in fodder.

Season	Watersheds					
	I	II	III	IV	V	I-V
Summer	1	0	0	0	0	1
Winter	2	0	1	0	1	4
Whole year	1	2	10	3	3	19
At present no use	2	2	2	1	2	9

Tab. 5.28: Number of seasons mentioned for grazing

The high number of herdsmen not using the forest for grazing at the time of the interview resulted from the high dynamics of building up herds and selling cattle. Cattle are sold if a disease threatens their value. People often gave the "Blue Tank Disease" as a reason, which forced them to sell their cattle (goats and sheep).

The trend to a very frequent access to the hillock for grazing becomes visible in table 5.29. Half of the herdsmen entered the forest daily with their cattle. In the entire area only 21% went less frequently.

Frequency	Watersheds					
	I	II	III	IV	V	total
Daily	50	50	46	75	50	52
More than once a week	17	-	8	-	-	6
Weekly	-	-	8	-	17	6
More than once a month	-	-	-	-	-	-
Monthly	-	-	-	-	-	-
Less than monthly	-	-	23	-	-	9
Not in the last five years	-	-	-	-	-	-
At present no use	33	50	15	25	33	27
No answer	-	14	-	-	-	1

Tab.: 5.29: Frequency of entering the forest for grazing in %

All watersheds were used for grazing (table 5.30). WS III, which also houses the highest number of herdsmen, was used the most. But surprisingly WS IV came in second place. The cattle keepers of this watershed used it all and 5 out of 13 herdsmen from WS III used it as well. The least frequented watershed was WS II.

User in WS	No of users	Collection in RF of watersheds					
		I	II	III	IV	V	Entire hillock
I	6	5	-	-	-	1	-
II	4	2	4	1	-	-	-
III	13	-	1	9	5	-	-
IV	4	-	-	-	4	-	-
V	6	-	-	-	-	6	-
sum	33	7	5	10	9	7	0

Tab.5.30: Watersheds used for grazing

All interviewed herdsmen together grazed 642 heads of cattle in the Kadavakurichi RF of which 369 were goats. Most of the herds were smaller than 20 animals while the most numerous herds among all herd sizes were placed in WS III. The big herds (>20 heads) inhabited WS I, IV and V. The highest number of goats occurred in WS V and III while most of the sheep were in WS II. Dung cattle stayed only in WS I and III (appendix 5.9).
According to the frequency of grazing and the watersheds used (see chapter 4.2.2.5), figure 5.15 shows the number of cattle grazed in the different watersheds per day.

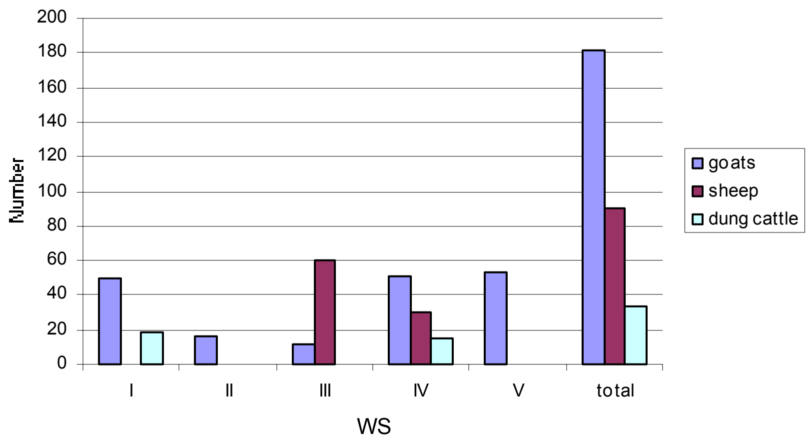


Fig. 5.15: Daily access through cattle of the questioned herdsmen

All together around 300 head of cattle of the users questioned entered the hillock daily. Together with the cattle of the herdsmen having not being interviewed a number of 600 cattle can be estimated. WS IV was the most often frequented watershed. 96 heads of cattle belonging to the interviewed people graze here every day.
The grazing of the goats was spread almost equally among the watersheds yet WS I, IV and V were used more intensively. WS II has the smallest number of cattle entering its Reserved Forest. Sheep only graze in WS III and IV while in WS III twice as many as in WS IV are grazed.

The cattle were concentrated on the lower parts of the hillock (table 5.31). Most of the people stated that they graze them under 400 meter elevation. Goats were spread over almost all areas and 7 herdsmen even said that they have their cattle graze everywhere, while for sheep and dung cattle clearly lower parts were preferred.

	<300	<400	<500	<600	>600	Every-where	Don't know	Total
Goat	6	6	4	4	1	7	1	29
Sheep	5	1	2	0	1	1	0	10
Dung Cattle	1	1	0	0	0	0	0	2
Total	12	8	6	4	2	8	1	41

Tab.: 5.31: Number of areas mentioned for grazing according to elevation

During the study period the grazing of cows could be observed. On the 11th December 1999 a boy from Kombaipatty grazed 8 cows on a lower elevation of WS III. He said, he goes there for grazing the cows, when the tank is filled with water. Cows were also found to graze in WS IV during the vegetation survey and on the 15th of December 2000 in WS III. These cows were without herdsmen. They were led there in the morning by the people in the forest and had to find their way back in the evening by themselves. Households following this grazing pattern had not been among the sample and can be taken as less representativ in the study area.

Used species, plant parts and amount

Asked for the most important fodder plants the herdsmen mentioned for sheep and dung cattle grasses most often. For goats shrubs and trees were named as most important (table 5.32).

	Goat	Sheep	Dung cattle	Total
Grasses	3	8	2	13
Shrubs	9	1	-	10
Trees	7	-	-	7
Herbs	1	-	-	1
All plants	4	-	-	4

Tab.: 5.32: Frequency of naming of plants most important for grazing

On the question about the species grazed shrubs were named 36 times and are therefore the preferred plants for grazing. The shrub species, which were mentioned mostly, were *Flueggea leucopyrus*, *Jasminum sessiliflorum*, *Acalypha fruticosa*, and *Pterolobium hexapetalum* (appendix 5.8) *Flueggea leucopyrus* was the most common shrub on the hillock, *Acalypha fruticosa* was present in 122 out of 500 sample plots, *Jasminum sessiliflorum* and *Pterolobium hexapetalum* only in one fifth.

Among the trees it was again *Commiphora berryi*, which was the most often named tree species (in 12 out of 21 cases). All other tree species were not mentioned more than twice. The named grass species are the most common grasses on the hillock (*Themeda cymbaria* and *Heteropogon contortus*) but together they where named only three times.

Beside this, many unspecific answers like “grasses” and “all (woody) plants” were given.

Regarding the browsed plant parts goats were named to eat the leaves and the soft sprouts of the woody plants. This gives the browsed plants, according to the intensity of the grazing, a depressed habit. The bark was never mentioned.

The amount of fodder the cattle consume could not be determined by asking the herdsmen.

Purpose of grazing and shortage

The purpose of grazing had not been asked, because this was definitely the feeding of the cattle. The cattle are an indirect product, which is gained. In the case of the dung cattle they are used as an income for the service of cleaning and fertilising the field. Goats and sheep are generally sold.

Asked if they find enough fodder, 48% of the grazers stated that they have a shortage in fodder supply while grazing in the forest. Most of them were in WS I where 83% did not find enough fodder. In WS III, where most of the cattle were placed, only 31% felt a shortage (table 5.33).

WS	No shortage		Shortage						
			Whole year		Summer		Total		Sum
	n	%	n	%	n	%	n	%	n
I	1	17	1	17	4	67	5	83	6
II	2	50	-	-	2	50	2	50	4
III	9	69	2	15	2	15	4	31	13
IV	2	50	-	-	2	50	2	50	4
V	3	50	-	-	3	50	3	50	6
Total	17	52	3	9	13	39	16	48	33

Tab.: 5.33: Shortage of fodder in the different seasons

The shortage occurred in most cases during the summer, when the herbal plants are dry or have disappeared and some of the woody species lose their leaves and do not have fresh shoots. Only in WS I and III did people perceive a fodder shortage also in winter.

Other sources and ideas for improvement

40% of the herdsmen did not give another pasture apart from the RF. People who have alternatives were mainly in WS I, III and V, the watersheds with the highest number of cattle keepers. Among all watersheds agricultural land was the main alternative grazing ground to the forest. This includes not only the grazing of fields after the harvest, but also their edges. In WS III the tank plays again an important role, as it did for the collection of fuelwood.

One third of the herdsmen did not know how to improve the amount of fodder. Eight people said that more rain would be needed and six recommend the cultivation of fodder plants. Among the latter, most people said grasses and trees had to be planted on the hillock or on wasteland and riversides. Only one reported that he cultivated fodder on his own land already.

5.2.2.3 Green manure

The collection of plants, with a fertilising effect, could be observed in and around the study area. In the flat open fields and on wasteland the subshrub *Tephrosia purpurea* was the most often collected species. It grows in open areas and wastelands, where groups of women cut them year by year. From discussions with village people and PHCC staff, it could be learned that green manure as a fertiliser for agricultural land was beeing increasingly substituted by mineral fertilisers during the last years. Therefore the importance of this product on the local marked stagnates.
The collection of green manure in the Kadavakurichi RF was practised almost only by users from one village, Kulipatty in WS III. Out of all users 11% (24 people) utilised green manure in the forest. 19 were based here. For them the green manure collection was the main product they gained from the forest (table 5.17 and 5.18). The caste distribution shows a different structure as the one of the fuelwood collectors and graziers. The main castes are Naidu (33%) Chettiar (25%) and Nayakkar (17%). Most of the people involved in green manure collection were between 19 and 40 years and of female gender.

Season, frequency and locality of use

All of the collection was done in winter, when after the rains the plants are available.
Within this season, almost half of the people entered the forest daily to collect the product. The other half said to a greater proportion that they go less than monthly. Considering that the growing season of these plants is only four to five months long (Sept.-Dec./Jan.), this seems very ineffective.
The green manure was collected in almost all cases in the RF within the own watershed. This makes WS III the main source for this product (table 5.34).

User in WS	No of users	Collection in RF of watersheds					
		I	II	III	IV	V	Entire hillock
I	1	1	-	-	-	-	-
II	1	-	1	-	-	-	-
III	19	-	-	19	-	-	-
IV	1	-	-	-	1	-	-
V	2	-	-	-	1	1	-
Sum	24	1	1	19	2	1	0

Tab.5.34: Watersheds used for green manure collection

Within WS III the collection was concentrated on the lower and middle part while five people said to use the entire watershed.

Used species, plant parts and amount

11 species were named to be collected as green manure. Among them four were shrubs, three were trees, three were subshrubs and one was a herbal plant. Two of the users said to use all herbal plants and one of the species mentioned could not be identified.
The most often named species were the subshrubs *Orthosiphon thymiflorus* and *Tephrosia purpurea*. They were present in 38 and 18 percent of the 500 vegetation plots respectively.
The most often named shrub species were *Acalypha fruticosa* and *Cassia auriculata*. The first one was the second most frequent shrub in the forest (24% of all plots) while the latter occurs only in 4% of all plots. The mainly used tree species was *Wrightia tinctoria*. This species was scattered over the entire hillock and occurred in 4% of all plots with not much difference among the watersheds. But in WS III, which was mostly used for green manure collection, it had its lowest pro rata occurrence (2.7%) (see appendix 5.3, table 1).
As most important as a source of green manure were mentioned by most of the users *Tephrosia purpurea* and *Orthosiphon thymiflorus*. Only five users named other species.
To get fertiliser, most of the used subshrubs got removed completely. 13 times people said that they use the entire plant, including roots. From the shrubs most of the users took the whole part of the plant above the ground and from trees mainly the leaves and sprouts were used. In contrast showed almost all utilised subshrub species, except *Tephrosia purpurea*, in WS III the highest average volumes. But the differences to the other watersheds were in general small. *Wrightia tinctoria* showed on average with 5.61 m³ a smaller crown than the average value in the watersheds (8.14). But if this was due to green manure collection can not be proved.

17 of the questioned green manure collectors gave the amount of plants they collect in the forest (5.35).

n	17
Average	23,31
Standard Devi.	13,05
Don't know	7
Outlier	1

Tab.5.35: Collected amount of green manure per visit to the forest in kg

The biomass removed from WS III was calculated for the people who enter this watershed daily for green manure collection (7) with the average per capita amount for five month (Sept. –Jan) and 30 days per month. This leads to 24,150 kg of removed biomass for the entire watershed and 78 kg per ha. Taking into account that only half of the collectors were interviewed and that the ones who stated that they went less than daily had not been included, the estimated amount has to be doubled at least.

Purpose of collection and shortage

Raising income was clearly the main objective. 95% of all green manure collectors sold this product and 11% used it for themselves.
75% of all green manure collectors and 74% of the ones in WS III did not feel a shortage in green manure supply. Only 5 of the 19 collectors in watershed III were not satisfied with the amount they find. The productivity of the hillock in biomass depends on the annual rainfall. The perception of the year 1999, which includes most of the rain of the last collectiong season, was with 630 mm (measurement at the PHCC centre Batlagundu) beneath the annual average. More rainfall could lead to greater satisfaction with the supply of green manure. However, the demand for green manure lies not too far beyond the productivity of the forest.

Other sources and ideas for improvement

Almost 40% among all collectors did not have a source of green manure other than the forest. In WS III 26% were without another source. The main alternative sources were wastelands.

Higher rainfall as an assumption for more supply of green manure was mentioned by seven of the green manure collectors and was therefore one of the most named points. Seven people also said that green manure plants should be cultivated. Most of them thought of sowing the seeds of Korinji (*Tephrosia purpurea*) in the forest. One exception was the statement of one person who said that a prevention of grazing is needed and another one who said that a higher supply can be achieved through a more intensive collection only.

5.2.2.4 Honey

Honey collection in the forest and other parts of the region is widely practised in the Palni Hills and the surrounding areas. In most cases just equipped with a rope, a big knife and a pot to carry the honey in, the collectors search for bee colonies which are often hanging on big rocks. They climb the rock and try to reach the colony from the top, chase away the bees with smoke and then remove the whole honeycomb. This work is dangerous. Often people get hurt themselves in accidents or get attacked by bees. The honey is sold to small agencies.

18 people (8%) among the users questioned collected honey in the RF of the study area. 13 of them were placed in WS III and 4 in WS I. For most of the collectors in WS III honey was the main product taken from the forest while the users in WS I gave it second priority (table 5.17 and 5.18).

90% of the honey collectors belonged to the Moopar caste and were without exception male and almost all between 19 and 40 years, while most of them are not older than 30 (appendix 5.6, table 1-3).

Season, frequency and locality of use

Most honey-producing plants flower after the rains which makes winter the main season for honey collection. But 7 persons collected throughout the year.

The frequency of entering the hillock for honey collection varies widely as a third of the people go weekly.

The collection did not take place in a specific watershed. If the users mentioned a watershed that they prefer, then it was the honey collectors from WS I who went to WS II, IV and V but not to their own watershed. The honey collectors from WS III preferred to collect on the entire hillock. Among the watersheds, WS V was most often specified. The reason for this is found in the “Honey Rock” (local name: then pari) of WS V, a steep, huge rock on the top of the hillock exposed to the East which was a place of many bee colonies (table 5.36).

User in WS	No of users	Collection in RF of watersheds					
		I	II	III	IV	V	Entire hillock
I	4	-	-	1	2	3	-
II	1	-	1	-	-	-	-
III	13	-	-	1	-	-	12
IV	0	-	-	-	-	-	-
V	0	-	-	-	-	-	-
sum	18	0	1	2	2	3	12

Tab.5.36: Watersheds used for honey collection

Most of the honey collectors said to collect honey at all elevations. Only two concentrate on an area above 600 meters in WS III and one below 400 meters in WS II.

Used amount

The honey was sold by weight, so the amounts given by the collectors can be considered as reliable (table 5.37).

n	13
Average	4,2
Standard Devi.	3,5
Don't know	3
Outlier	2

Tab.5.37: Collected amount of honey per visit to the forest in kg

For the calculation of the total amount the index for daily entry of table 4.8 was used. People who went less than weekly were excluded. This leads to a collected quantity of almost 30 kg per day by the people questioned, or more than 200 kg a week and over 4000 kg during the winter. Counting all people who collected honey on the Kadavakurichi it adds up to twice that.

Purpose of collection and shortage

The most important motivation for gaining the product was the raising of income. 78% of all honey collectors sell the product. 8 of them in WS III even gave the collection of honey as their main occupation (appendix 5.5, table 2) while only 4 stated that the reason for collecting the honey was own consumption.

For most of the collectors the honey supply of the forest was not enough. 56% of all and almost 70% of the honey collectors in WS III were not satisfied with the quantity they gained. They felt the shortage mainly in summer. Not only did the honey-producing plants in the forest flower less during this season, it is also a fact that cultivated flowers represented an additional source in winter.

Other sources and ideas for improvement

A high demand for honey and a shortage of production raise the question of available alternatives. They exist for 78% of all questioned people.
The main sources were coconut fields, surrounding hillocks and the Palni Hills. Coconut fields were available within the study area. To reach other hillocks or even the Palni Hills means much more effort.

Almost half of the 18 honey collectors didn't have ideas for increasing the amount of harvested honey. Five said they don't know and three said that nothing could be done. Among the named possibilities, the stimulation of the flowering plants in the forest was mentioned most often. In addition one person said that more rain is needed to get more flowers and one person mentioned the improvement of honey producing plants outside the forest. Four people had ideas regarding the equipment. Two think that providing beehives could lead to more honey yield and two say that a more effective collection in the forest would lead to a greater supply of honey. One man made the statement that either the forest had to be improved or beehives should be provided to the honey collectors.

5.2.2.5 Medicinal plants

Medicinal plants play an important role in the Indian folk medicine and therefore it was expected that great importance is attached to this product. But the use of medicinal plants in the Kadavakurichi RF was quite limited.

Among the strata “others” were 13 collectors of medicinal plans. All of them were placed in Kombaipatty in WS III. For most of them this product was the most important, whereas for five it ranked in second or third place (table 5.17 and 5.18)
12 of these 13 users belong to the Moopar caste. Among all people involved in the collection of medicinal plants of the studied households, 18 out of 22 were children (appendix 5.6, table 1-3). They go to the hillock in winter usually before school starts, and collect medicinal plants to sell them and to improve their pocket money

Season, frequency and locality of use

Winter was clearly the season for the collection of medicinal plants. Only two out of 13 collectors collected throughout the year. Most of them did not collect daily, but more than once a week.
All of them used their own watershed only, which makes WS III the used watershed used most for medicinal plant collection. 9 of the 13 collectors said not to collect above 400 meters elevation and only one used the entire watershed.

Used species, plant parts and amount

Three species were named for use as medicinal plants: *Barleria longiflora*, *Ocimum tenuiflorum* and *Orthosiphon thymiflorus*. All of them are subshrubs and were the most common ones in the forest. They occurred in WS III equal to or above the average frequency on the hillock (appendix 5.3, table 1). *Orthosiphon thymiflorus* was the most important species. Every user mentioned it as a collected species and all of them named it as the most important one.
The most often mentioned part used from subshrubs was leaves. Only twice the whole plant was said to be collected. The volume that the species amounted to in WS III was the same as mentioned for the green manure collection: with little difference to the other watersheds held it here the highest average volume.
Except two outliers, who reported an unrealistic amount of collected medicinal plants, 11.54 kg was used on average per head and visit to the forest. Most of the given amounts do not vary much from this average.
A brief calculation using the index from table 4.8 leads to 46 kg of medicinal plants collected in WS III per day. This sums up to 6440 kg for five winter months in total and 22.3 kg/ha. This is much less than the collected green manure.

Purpose of collection and shortage

12 out of the 13 users of medicinal plants sold the collected material. Only one consumed it in his own household.
Only 2 of the 13 interviewed persons felt a shortage for medicinal plants. The reason could be that for most of the users the collection was not an important income but more of an additional pocket money so that there was no real need for collection.

Other sources and ideas for improvement

Except one, who did not know what to say, all collectors said that they did not have another source for medicinal plants other than the hillock. But *Orthosiphon thymiflorus*, the most often used species, grows on wasteland and other open spaces also. That it is not collected from there is another indicator for the limited demand for this product.
Most of the medical plant collectors (7) think that more rain is needed to improve the productivity of the forest for this product. Three didn't know what to say and two thought of planting the required species in the forest.

5.2.2.6 Fence material

The fencing material consists of branches from thorny species, required to keep cattle. It is never collected as the main product. Only nine of the forest users cut fence material in the forest and out of these 8 were from WS III (table 5.17). Almost all of them are Moopar in the age of 19 and 60 years (appendix 5.6, table 1-3). Except one, all of them were males. Three do not keep cattle, while six have herds larger than seven heads.

Season, frequency and locality of use

Material for fencing was collected throughout the year. Only two people prefer the summer for the collection. It is only needed if a herd is going to be established or if the old fence has to be improved. This does not happen on a big scale and therefore the demand and the frequency of use was low. All users went to the hillock less than once monthly.
All the fence material was collected in the RF of the watershed the collectors are living in, which makes WS III also for this product the mainly used watershed. Within the watershed the collection was not concentrated on a specific area.

Used species, plant parts and amount

All together seven species were mentioned to be collected for fence construction purposes. 15 times shrubs were named. The most often mentioned one was *Flueggea leucopyrus*, which was also the most frequent shrub species in the vegetation survey and equally distributed to the different watersheds (appendix 5.3, table 1). *Dalbergia horrida* which was named five times, did not occur in a single one of the 500 vegetation plots and could not easily be found if searched. Only three times trees were named. These are two species: *Commiphora berryi* and *Commiphora caudata*. *Commiphora berryi* was the main tree species and its branches can be used as cuttings. Put in the soil and irrigated they can grow to a new plant and then form a permanent living fence. Asked which of the species was the most important, almost all persons named *Flueggea leucopyrus.*

From shrubs and trees mostly the branches were used, but *Commiphora berryi* and all shrub species, mainly *Flueggea leucopyrus*, were also used as entire plants above the ground.
The collected amount was not much in total. 6 of the 9 persons gave a valid statement, which leads to an average of 45 kg with a small standard error. Compared with the amount of firewood collected, this seems to be an overestimation. It could be that the persons gave the amount they use to construct one fence and not their collection per visit to the hillock. Regarding the removed biomass from the hillock the total amount used seems negligible.

Purpose of collection and shortage

Out of the nine collectors of fence material, 7 used the product themselves and only two sold it. Not one of the questioned users felt a shortage of fence material in the forest.

Other sources and ideas for improvement

Two persons said that they also collect the product on agricultural land. All others use only the hillock.
Only three out of nine persons made suggestions for an increase of the product supply. The three statements were: cultivation of the needed species, the protection of the forest and the need for more rain.

5.2.2.7 Thatching

Grass from the forest to cover the roof of a house is the cheapest material for this purpose. As shown in chapter 5.2.1.2, this method is not used much at present. Only 9 persons among the interviewed users utilised this product from the forest, 7 of them were from WS III and for only one was it the main reason to enter the forest (table 5.17 and 5.18). 90% of the collectors belonged to the Moopar, their age lies between 19 and 60 and most of them were of male gender (appendix 5.6, table 1, 2 and 3).

Season, frequency and locality of use

Summer is generally the time to collect the grass, which then has its full size and is dried so that it can be used right away. 5 out of the 9 grass collectors concentrated their collection on this season. Two went during the entire year and two said that they collect only in winter.
The frequency in which the hillock was approached for the collection varies. Five said that they collect less often than monthly while the other four went weekly or even more often than this.

Almost all grass collectors cut the grasses in their own watershed (table 5.38).

User in WS	No of users	Collection in RF of watersheds					
		I	II	III	IV	V	Entire hillock
I	1	1	-	-	-	-	-
II	-	-	-	-	-	-	-
III	7	-	1	6	-	-	-
IV	-	-	-	-	-	-	-
V	1	-	-	-	-	1	-
sum	9	1	1	6	0	1	0

Tab.5.38: Watersheds used for grass collection

The places, where the required grasses are present in their highest density are the frequently burned grasslands. But these areas were not clearly named by the grass collectors. The user from WS I collected it in his own watershed up to an elevation of 500 m and the one of WS V did the same in his watershed. From the seven users in WS III only 2 collected above 500 meters and one uses the entire watershed.

Used species, plant parts and amount

All used plant species collected to cover the roof were grasses. No one of the questioned people named more than one species and this was therefore also the most important one. The most often named species was *Themeda cymbaria*. It is the dominant species on the annually burned grasslands and also very often present in the herbal layer in other parts where fire occurs. In the vegetation survey it was found in 27% of all plots while it had its highest frequency in WS II, I and V (appendix 5.3, table 1). The grasses are used completely and cut above the ground.
On average the people said to collect 31 kg per entry in to the forest while one third said to go less than annually. This does not lead to a heavy loss of biomass. The question regarding the influence of grass collection is rather more one of looking at the possible connection with fire. This user-group was the only one that utilised the product created by the fire on the grassland and therefore they should have an interest in keeping them in the condition they are. But, if at all, only a few were using these areas for the collection. As seen in chapter 5.1.5 did the grasses not show any cutting signs. This leads to the assumption, that the gaining of thatching material was not the main reason for the occurrence of fires.

Purpose of collection and shortage

All households used the thatching material for themselves and only one person in WS III was selling it.
The oversupply of grasses should satisfy the need of all the grass cutters, but still 30% felt a shortage. These were people in WS I and WS III, both watersheds where grasslands occur.

Other sources and ideas for improvement

Only two people named an alternative source: the collection from agricultural land.

The nine collectors of thatching material gave a wide range of answers regarding the improvement of grass supply. Two think that a need of improvement does not exist while two said that grasses could be cultivated. One had the opinion that the protection from fire helps here while one said that after a fire fresh grass grows. Another person said that the protection from grazing will improve the grass supply and one more person has the opinion that more rain is needed.

5.2.2.8 Small timber

Timber is the product, which may be considered as the main form of forest utilisation. The term small timber means poles and other construction parts, which are used for small construction purposes. The demand of this product in the form of long poles, not more than 15 cm in diameter, is high. Almost every household in cities and in rural areas needs it for small enlargements of their buildings through a temporary hut or a roof made of coconut leaves. This construction was also needed to create small temporary shelters for family or cultural feasts.

The trees in the Kadavakurichi forest did not have the quality of this type of small timber. The stems utilised there were short and not very straight. They are used for small constructions like roofs in front of the houses, bathing places and for other similar purposes. An old man in Kamatchipuram showed the author that the roof beams of his house are made out of *Euphorbia antiquorum* and said that in earlier times it was usual to make them this way. But today wood out of the Kadavakurichi can be seen very rarely in constructions in the villages of the study area.

Only five people among the interviewed users collect small timber in the forest. Four of them were from WS III and one was from WS I. For none of them was it the main product (table 5.17 and 5.18).

All were male, all were Moopar and most of them were below 40 (appendix 5.2, table 1, 2 and 3)

Season, frequency and locality of use

There was no specific season in which small timber was felled. Four out of the five users did it during the whole year. The frequency of collection was low. Only one person said that he went more often than once a month and all others procure timber gain less than monthly.

WS I, II and III were used for small timber collection by the interviewed users. The mainly frequented watershed was WS III. In WS II and III small timber was collected mainly at the top. The user in WS I collected at the bottom of the hillock.

Used species, plant parts and amount

Seven tree species were named as being used for small timber. Frequently they were *Commiphora berryi*, *Erythrina suberosa* and one species that could not be identified. In contrast to *Commiphora berryi* as the main tree species did *Erythrina suberosa* occur only in three plots, two of them in WS II and one in WS III. Small groups of this species exist on the top of the hillock on the border of WS II to WS III.
The species that were named as most important were *Erythrina suberosa*, *Chloroxylon swietenia*, *Commiphora berryi* and the unknown species. The first can be seen in small constructions quite frequently and mostly in Kurumbapatty (WS II) and Kombaipatty (WS III) while *Chloroxylon swietenia* was used to manufacture the common digging tool (mumpatti).
The timber used in constructions seen in the villages was in almost all cases the full stem of a tree. But most of the collectors said to use only branches and only three times the use of the whole plant was mentioned.
The stated collected amount varies from 5 to 75 kg and was on average 48 kg. These data have to be treated carefully because the selling is not done by weight and they are small in number.
The removed biomass by five people in three different watersheds with a relatively low frequency can be assumed not to be much. The influence on the vegetation compared with the influence of fire and fuelwood cutting seems to be negligible

Purpose of collection and shortage

Three of the small timber collectors said they sold the product and four used it for their own need.
Two of the collectors said they did not find enough timber on the hillock. Both of them were timber sellers. The lack they perceive may concern the good quality timber they need for selling.

Other sources and ideas for improvement

Other sources for small timber were agricultural land and the tank in WS III. Two of the timber collectors did not use other sources.
Of the five timber collectors three said that the supply of timber could be improved by tree planting and one added that the forest also has to be protected from grazing. One said that the wood cutters should be controlled.

5.2.2.9 Hunting

The methods for hunting are simple. Animals, mainly rabbits, are attracted by night with torchlight's and caught manually, or traps made out of wire are put on the path of the rabbits.
Among the interviewed persons were two people who hunt in the forest. One from Veelinayakenpatty in WS I and one from Kombaipatty in WS III. For both, hunting was the main use of the forest (table 5.17 and 5.18). They both belonged to the Moopar caste and were of male gender (appendix 5.6, table 1 and 3). Both said that they went more often than once a month for hunting. One preferred the winter and one hunted throughout the year. The hunter from WS I used WS I and V while the one in WS III said to hunt in WS IV. Spoils were rabbits and wild cats. On average they got 12 kg venison per hunt. One of them had shortages in winter. One has agricultural land as an additional source. Both are selling what they hunt and one was also using it in the own household.
One of the questioned hunters said that if he could get a farm, he could breed the animals on his own and could therefore get more venison.

5.2.2.10 Roots

One man among the users collects roots in the RF. He came from Kamatchipuram in WS I and belonged to the Moopar caste (appendix 5.6). This product ranks in third place of importance among the products he used. In winter, he went monthly for this purpose to the hillock and dug the roots of the herb *Dioscorea oppositifolia* (Local name: Valli Kilangu). He said he collected 20 kg of this plant for his own purpose each time he went. He had no shortage and no other sources to collect the plant.
The root collector said, that a cultivation of the plant he was using is possible, but it would be too much effort.

5.2.3 Forest fire

The present uses were described and their socio-economic context was shown in chapter 5.2.2. But the forest fires, the influence which reduces the biomass in the strongest way and which, if used uncontrolled, allows only limited opportunities of forest management, had not been represented in this way. Too do so the people who lit the fires would have to be identified in order to research their motives and the purpose of their action. Only if the cause, pattern and the purpose of these fires are understood, the opportunity for a regulation of it as a foundation for holistic forest management can be implemented successfully.

5.2.3.1 Reasons for forest fire

During the time in which this study was carried out, it was not possible to find any person who was involved in the use of forest fire. To burn the forest is illegal and the forest department punishes the fire raiser if he is discovered. This makes it hard to reach these people personally. To get at least an idea of the possible reasons leading to the forest fires, all questioned people were asked why the fires occur on the hillock and their opinion on the fire. It was possible to give more than one reason. Table 5.39 shows the reasons for fire given by the questioned people of each user group.

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Reasons for forest fire	Fuelwood	Cattle	Others	Users total	Non-users
Don't know	20	51	40	29	27
Careless Smokers	25	24	18	23	11
Herdsmen	23	8	20	20	14
Somebody	19	16	16	18	15
Fuelwood cutters	16	14	16	16	13
Honey collectors	12	8	7	10	3
Children	6	11	4	7	5
Natural	4	0	7	4	6
Charcoal producers	4	14	0	5	1
Someone making rain	1	0	4	2	2
Careless people	1	0	0	<1	0
Hunter	1	0	0	<1	0
It comes from other areas	0	3	0	<1	0
There is no fire on the hillock	1	3	9	3	8
No answer	0	3	0	<1	4

Tab. 5.39: Frequency of reasons for the forest fire in percent (more than one answer was possible)

Of the users as well as the non-users, most people said they did not know the cause of the fire. This is surprising with respect to the users, which are known to be in the forest regularly and therefore in touch with the activities there. The unspecific answer “somebody” ranks in forth place. Here the users held the higher ratio, also.

The smoking of beedies, hand-made small Indian cigarettes, and their careless handling in the forest and herdsmen who use the fire to create grazing ground and to keep the forest open is the dominant opinion among the users. But of the people who are mainly involved

in grazing only 8% gave the herdsmen as a reason. Besides “don’t know” and “somebody”, most of the non-user think that herdsmen are responsible for the fires.
That people who collect fuelwood burn the forest for their purposes was also one of the more frequently named reasons. Among the persons out of the strata “fuelwood”, the group that would include here the potential firelighters, still 16% mentioned this reason.
Honey collectors use fire to create smoke and chase away the bees so that they can harvest the honeycombs. The opinion that the fires are caused by this practice is spread more among the users than the non user. Among the honey collectors themselves nobody gave this as a reason.
That people who collect the bark of *Euphorbia antiquorum* for the production of charcoal are responsible for the forest fires was believed by 5% of the users while the non-user do rarely take this into account. Other named reasons are the intention of the fire lighters to cause rain, hunters, other causes from outside the area and just careless people.
Only a minority of people say that fires do not occur on the hillock with a slightly higher ratio among the non-users.

5.2.3.2 The opinion on forest fire

In an open question, the people were asked about their opinion on the forest fires to see if they have positive or negative attitude to it.
The given answers of forest users and non-users were sorted into clusters. The criteria for these clusters were formed using the people’s view of the effect of fire on the forest and on the people.

Almost a quarter of all questioned people had no opinion on the fire. The ratio among the users was slightly less than that of the non-users.
In total, 42% of the questioned people saw a negative effect of the forest fires on the vegetation. Among the users, the rate was much higher with 50% than the one of the non-users with 34%. That fire is harmful in general or cause of damage to the forest believed another 11% of the users and 9% of the non-users. That the fires are negative for the local people thought 6% of the non-users and only less than 1% of the users. A loss in benefit for the forest users see 3% of the first and 6% of the latter. The opinion, that the fires are negative for the herdsmen was the most often named among the users (nearly 4%). In the burning of grasses and woody plants they see a loss of fodder.
The opinion that fire is a benefit was rare. Only 3% of the users see a profit coming from the fires, the answers of the fuelwood collectors are the foremost in this category. Non of the non-user shared this opinion. A benefit in the form of rain that is caused by the fires see only 1% of the questioned people.

5.2.4 Influences on the forest from outside the study area

Besides the impact on the forest from the villages inside the boundaries of the study area, different influences originating outside the study area existed as well as those that could be discovered during the time the study was conducted are: shepherds from Ramanathapuram District (around 80 km's southeast of the Kadavakurichi), charcoal utilisation and timber harvesting.

Transhumance grazers

Five settlements form external herdsmen where found in the study area (see chapter 4.2.2.4). The settlements consist of 3 to 20 families who stayed for some months, except one who stayed permanently in the area. They said to come to the Kadavakurichi in August and to leave in January. They have herds of sheep with a size ranging from 300 to 2000 heads, which are taken for grazing daily.

These people play an important role in the supply of manure within the study area. Four of the five settlements provided dung to the local farmers and one said to get money for the grazing on the agricultural fields after harvest.

The Kadavakurichi did not seem to play a major role in their grazing activities. Only one settlement said that they use the Kadavakurichi hillock for grazing. All of them mentioned as grazing areas agricultural fields after harvest and wastelands. The fields are harvested around January, which means that in the time from August to January this relatively huge number of cattle only depends on wastelands. One said they previously used the Reserved Forest of the entire WS II but due to the pressure of the Forest Department they stopped it. One settlement said to use the forest of WS III and WS IV up to an elevation of around 400 meters for grazing. They keep around 2000 sheep. This adds to the impact on the watersheds, which are already used mostly for grazing by the village people (figure 5.11 and table 5.31). But the people from this settlement said, that they get to the hillock mainly in the rainy season to make use out of the freshly appearing grasses. They access the hillock only ones or twice. This habit raises conflicts with the people from the villages.

It is likely, that shepherds who have their temporary settlements outside the study area also frequent the hillock. Such herds can be observed around all Batlagundu and Nilakkottai in the winter season. They have mainly dung cattle and sheep.

Owing the lack of a footpath survey in the present study, this influence could not be located exactly. The PHCC found a higher impact by these people on the forest in 1991. But during the vegetation survey no of such cattle were observed. Mr. R. Subramania (Panchayat president Kombaipatty and head of the Village Planning Committee Kombaipatty, interview on January 26th 01) thinks that the influence of these shepherds on the forest is limited. They are in the forest from time to time, but the villagers make them leaving it again.

Charcoal collectors

On November 4th 1999 the author met two people in the forest of WS II, who broke the bark from *Euphorbia antiquorum*, put it in sacks and carried it to different places where it was processed into charcoal. The bark could be removed easily from the trees due to a fire, which had occurred on September of the same year.

Fig. 5.16: Charcoal kiln at the Kadavakurichi RF two months after a fire

There was nobody there to translate for the author and therefore it was not possible to question these people. During enquiries among the PHCC staff, local people and in the interviews with Mr. R. Subramania, the following picture of charcoal use in the Kadavakurichi RF appeared: The charburners came from Semmetupatty (5 km's southwest of the Kadavakurichi hillock). Mr. Subramanian said that he met six people from this village on the hillock three years ago and sent them away. He observed that they came often after an outbreak fire, but he did not know if they caused the fire. The charburners came early in the morning by bus and hike, collect the bark from *Euphorbia antiquorum* and, after processing it, carried it directly to Nilakkottai and sell it to goldsmiths who have a colony there. The goldsmiths request the charcoal of the bark of *Euphorbia antiquorum* because of its steady and even flame.

If the activity of the charburners is limited to the collection of the bark, their influence on the vegetation should not be very high, because the used trees are already dead due the fire. But in case the charburners caused the fire in order to create suitable conditions for bark collection, their action is of strong impact on the vegetation.

Timber contractors

The information about companies doing organised and illegal timber felling in the Kadavakurichi RF was very limited. Mr. Murgesh who worked for the PHCC for almost 10 years in the Kadavakurichi area said, that before 1993 timber contractors regularly used WS III for the utilisation of *Euphorbia antiquorum* timber. These contractors only appeared for a day, felled a considerable amount of the bigger trees, removed the branches and left the stems in the sun to dry up and loose weight. After a few days they came back to collect the stems.
Mr. Subramania said emphatically that this never happened. It may happen that poor people use the *Euphoria antiquorum* stems as roof beams but he never saw organised groups doing so.

During the time of this study, any use of any forest product through organised groups could not be observed. But such an influence can not be excluded either, because it seems to be quite common in the plains as well as in the mountains of the region that illegal timber feeling beyond personal requirements happens.

5.3 Effects of forest use

5.3.1 Vegetation structure dependent on site factors

5.3.1.1 Probability with which the vegetation parameters occurred

To perform the linear regression, it was necessary to exclude the plots where the analysed parameter was 0 (see chapter 4.3.3). The model, which was created for the respective vegetation parameter is based on the formula:

$$\text{Logit}\ (w_i)=b_o+b_1x_1+b_2x_2+\ldots+b_ix_n \quad (11)$$

Logit(wi)	values to set in the logistic function (see below) which allow the attribution of estimation in the interval of 0 to 1.
b_o-b_4	regression coefficients
x_1-x_i	explanatory factors

An outlier exclusion through the definition of a residual interval was not done, because the percentage of excluded observations would have been too high.
Table 5.40-43 gives the output of the LOGISTIC procedure of the SAS program for the analysed vegetation parameters. They show the explanatory values, which were involved in the model to explain the respective vegetation parameter, their order of integration in the model, their significance and the –2-Log-Likelihood-value[1]. The –2-Log-Likelihood-value reports the grade of determination of the explanatory value. The smaller its difference to the –2-Log-Likelihood-value of the previous parameter, the smaller is the influence of the explanatory factor on the analysed vegetation parameter.

Wood volume index of trees (WV_P-tree)

Where wood volume is present it can be said that tree individuals exist. Accordingly there was no tree individual present if the wood volume was zero, defined as a value below 0.003 (table 4.14).

Explanatory variable (x)	Sequence of affiliation	Parameter		Significance	-2-Log-Likelihood-value after affiliation
Intercept		b_o	3.1598	0.0001	507
Elevation	1	b_1	-0.00488	0.0001	489
so1	2	b_2	0.3378	0.0003	481
so3	3	b_3	0.2774	0.0332	476
eo1	4	b_4	-0.1284	0.1062	474

Tab. 5.40: Parameter of the Logit-function for estimation of the non zero value probability of the wood volume index of trees (WV_p-tee)

Table 5.40 shows a low effect of the site factor on the presence of trees. The largest difference in the -2-Log-Likelihood-value given is for the elevation, which was therefore the main factor for determining the presence of trees. Its negative parameter in the model indicates that the probability of the occurrence of trees on higher altitude became less. This correlation was to be expected because grasslands were concentrated on the higher elevations.

[1] For the explanation of the abbreviations of the explaining factors please see chapter 4.3.1)

Crown volume index of shrubs (CV_P-shrubs)

The same applies for the crown volume of shrubs as for the wood volume index of trees. Where a crown volume was recorded, shrub individuals occurred, while a crown value of zero indicated the absence of shrub individuals.

Explanatory variable (x)	Sequence of affiliation	Parameter		Significance	-2-Log-Likelihood-value after affiliation
Intercept		b_o	0.1949	0.4918	662
so1	1	b_1	0.3466	0.0020	634
eo2	2	b_2	-0.3637	0.0005	623
Percentage of rock	3	b_3	-0.00833	0.0513	620
eo1	4	b_4	-0.01159	0.0567	617

Tab. 5.41: Parameter of the Logit-function for estimation of the non-zero value probability of the crown volume index for shrubs

This is where the soil texture showed the highest influence. So1 of the explanatory variable divides it into rock/rubble and sand/silt/loam (see table 4.10). If rock/rubble was present, the probability of finding shrub individuals was low.
The model also gives a significant influence to the existing exposure and the percentage of rock cover but with a very small percentage of determination power.

Biomass-index for subshrubs (SSV)

The model found that the highest determining factor for the occurrence of subshrubs was the relation to the depth of the soil. The shallower the soil, the smaller the probability of finding subshrubs. In addition they were more often found on the better soils (so1) and on southern exposures (eo2). But the determining power of these correlations was weak (table 5.42).

Explanatory variable (x)	Sequence of affiliation	Parameter		Significance	-2-Log-Likelihood-value after affiliation
Intercept		b_o	-1.14526	0.0001	690
Depth of soil	1	b_1	0.0243	0.0271	678
so1	2	b_2	0.3087	0.0164	671
eo2	3	b_3	0.02306	0.0184	666

Tab. 5.42: Parameter of the Logit-function for estimation of the non-zero value probability of the biomass index for subshrubs

Biomass index for grasses (GV)

Here the site influence was small (table 5.43). Distinguishing the northern and southern exposures showed that the northern exposures had the highest influence on the presence of grass (eo2). This points to the location of the grasslands in the upper elevations of WS I and II where the northern exposures dominate (see appendix 5.1).

Explanatory variable (x)	Sequence of affiliation	Parameter		Significance	-2-Log-Likelihood-value after affiliation
Intercept		b_o	-1.4418	0.0054	638
eo2	1	b_1	-0.3281	0.0029	613
Depth of soil	2	b_2	0.0342	0.006	607
Elevation	3	b_3	0.00329	0.0007	598
eo4	4	b_4	-0.3368	0.0497	595
so3	5	b_5	-0.1876	0.0329	591
so2	6	b_6	1.0648	0.0400	588

Tab. 5.43: Parameter of the Logit-function for estimation of the non-zero value probability of the biomass index for the grass layer

The influence of the other significant factors, depth of the soil, exposure and the soil texture, are negligible.

Successes of classification

The model sets by default 0.5 as the probability threshold for the classification. A plot with a probability value below 0.5 was classified as a zero value. A probability value of 0.5 and above led to a classification as non- zero. The numbers of plots estimated by the model for both classes are given in table 5.44.

Analysed parameter	Parameter present	Number of observed events	Estimated number of events at a critical probability value of 0.5		0.8	
			Present		Present	
			yes	**no**	**yes**	**no**
WV_P-tree	**yes**	407	401	6	293	114
	no	101	99	2	43	58
CV_P-shrub	**yes**	327	316	11	0	327
	no	181	154	27	0	181
GV	**yes**	345	332	13	90	255
	no	163	138	25	16	147
SSV	**yes**	213	59	154	0	213
	no	295	49	246	0	295

Tab.5.44: Observed and estimated number of plots for zero and non-zero values at different threshold probabilities

With a threshold of 0.5, the model estimated in almost all cases, that the tested parameters were present even where they were known to be absent. Subshrubs are an exception here. In order to adopt the estimation better to the observed events, the critical probability value was set to 0.8. This led to a shifting in the proportion of the estimated events but did not improve the quality of the estimation. For example the estimation of an absent crown volume of shrubs (CV_P-shrub) is in all cases correct, but for a present crown volume, which was observed in 327 cases, a positive event was not estimated at all. The result for occurrence of subshrubs is even worse. The model estimates that subshrubs were absent, whether they were present or not. The estimates of this model work best in the wood-volume index (WV_P-tree). But even here in almost half of the cases where there was an absent parameter, a positive event is estimated.

5.3.1.2 Influence of the site factors on the vegetation

To test the influence of the chosen site factors on the vegetation a linear regression analysis was carried out. The chosen model used the formula:

$$y_i = b_o+b_1x_1+b_2x_2+\ldots+b_ix_n \quad (13)$$

The plots showing a positive event for each respective vegetation parameter served as the database. Every site factor, which was significant for the formation of the vegetation, was included in the model.

The residuals of the different observations for each variable showed an even distribution for all tested variables. Figure 5.17 shows for example the residual distribution of the crown volume.

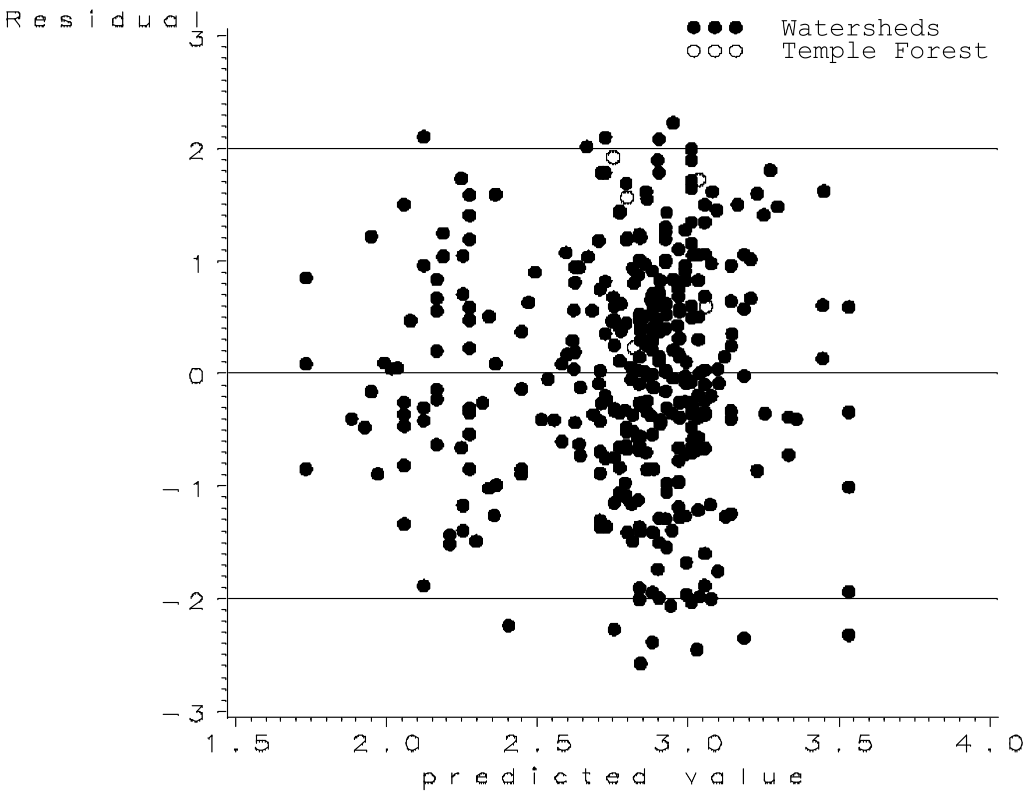

Fig 5.17: Residuals of the tree crown regression

The residuals of the variables represented in the 5% cover classes show a structured form and a straight line in the upper part. This is due to the 5% interval and the limitation of the values through 0 on the lower end and 100 on the upper. The zero values were excluded from the linear regression model and then analysed in the logistic regression. However, the limitation of an upper boundary is still obvious. This effect was not considered to be a serious disturbance to the model.

The parameter in formula 13 for the different site factors and its partial coefficient of determination r² for the analysed vegetation parameter was calculated (Table 5.45).

Independent variable (x)		Dependent Variable					
		% Cover biomass	WV_P-trees	CV_P-tree	CV_P-shrub	Subshrub volume (SSV)	Grass volume (GV)
Intercept	b_0	3.85808433	-4.66126851	2.24908695	-0.96167078	0.22935519	-1.13223125
Elevation	b_1	0.00035173	0.00329848	/	0.00179056	0.00222734	0.000279991
	r^2	0.03	0.07	/	0.07	0.02	0.12
Slope	b_2	/	/	/	/	/	/
	r^2	/	/	/	/	/	/
Depth of soil	b_3	/	/	0.02171181	/	/	/
	r^2	/	/	0.04	/	/	/
Cover of rock	b_4	-0.00502822	/	/	/	/	/
	r^2	0.08	/	/	/	/	/
so1	b_5	0.21282196	0.37661729	/	/	/	0.15864435
	r^2	0.42	0.06	/	/	/	0.02
so2	b_6	0.20920954	/	/	/	/	/
	r^2		/	/	/	/	/
so3	b_7	0.03666337	0.12996196	/	/	/	/
	r^2	0.01	0.01	/	/	/	/
so4	b	0.08010305	/	/	/	/	/
	r^2	0.01	/	/	/	/	/
eo1	b_9	-0.03440013	/	/	/	-0.27205427	/
	r^2	0.01	/	/	/	0.08	/
eo2	b_{10}	/	/	0.19959137	0.17256258	/	0.15110736
	r^2	/	/	0.03	0.06	/	0.02
eo3	b_{11}	/	/	/	/	/	-0.25165036
	r^2	/	/	/	/	/	0.03
eo4	b_{12}	0.04859009	/	0.31608344	-0.17604464	/	/
	r^2	0.01	/	0.02	0.02	/	/
Sum	r^2	0.58	0.14	0.09	0.15	0.10	0.19

Tab.5.45: Parameter (b) and partial r² for the determination of the vegetation parameters through the site factors

The site factor that was most often used by the model was the elevation. It influences all vegetation parameters significantly except for the crown volume of the trees. Its partial r² did not exceed 0.12 and has thus, even with a relatively high value compared to the other factors, a limited explanatory power for the vegetation. The depth of soil and the slope had very little or no explanatory power. The slope was never chosen as a significant factor to explain vegetation, while the depth of soil determined only the crown volume of the trees.
For the total analysis it can be said that the explanatory power of the chosen model was small with regard to the vegetation. The model indicates weak correlation between the site and the vegetation, which are shown in the figures that follows.

Cover with Biomass

The model rated the highest r^2 (0.58) for the percent of the covered area with biomass. Table 5.45 shows a partial r^2 of 0.45 for the soil texture of which 0.42 falls on bo1. It divides the soil texture in bad soils (rubble/rock) and better soil (sand/silt/loam) (Tab. 4.10). Figure 5.18 shows the regression lines for the coverage of biomass over the elevation for the different soil textures. The cover of living plants varied for different soil textures in such a way that it increased on better soil. The influence of the elevation was small but slightly stronger on the better soil textures.

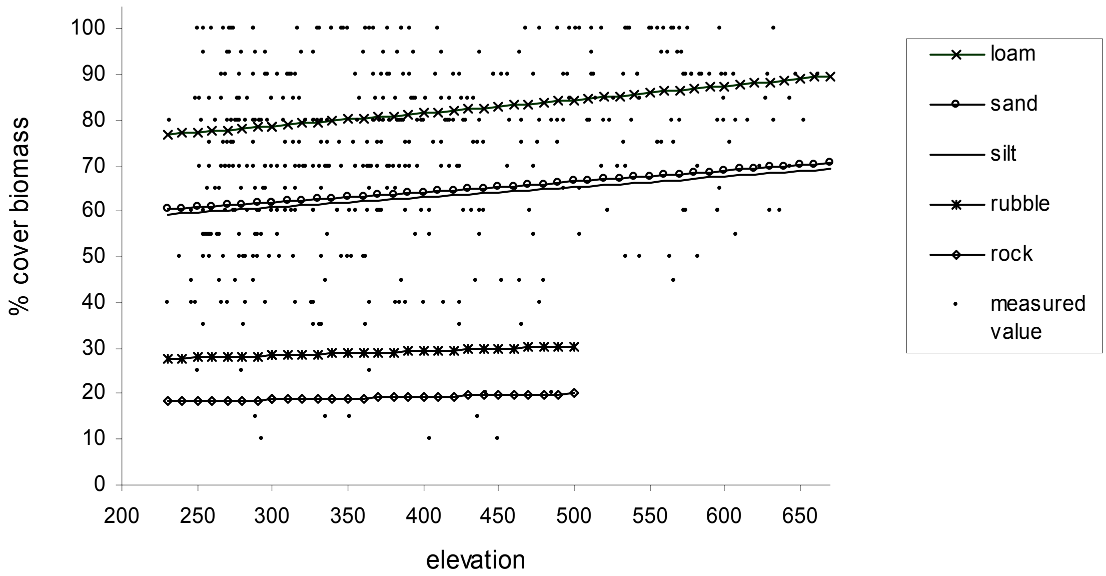

Fig 5.18: % of cover with biomass dependent on soil texture and elevation

Wood volume index of trees (WV_P-tree)

An effect of the elevation and the soil could be observed for the wood volume of trees. The amount of solid wood increased slightly with the elevation and on better soil texture.

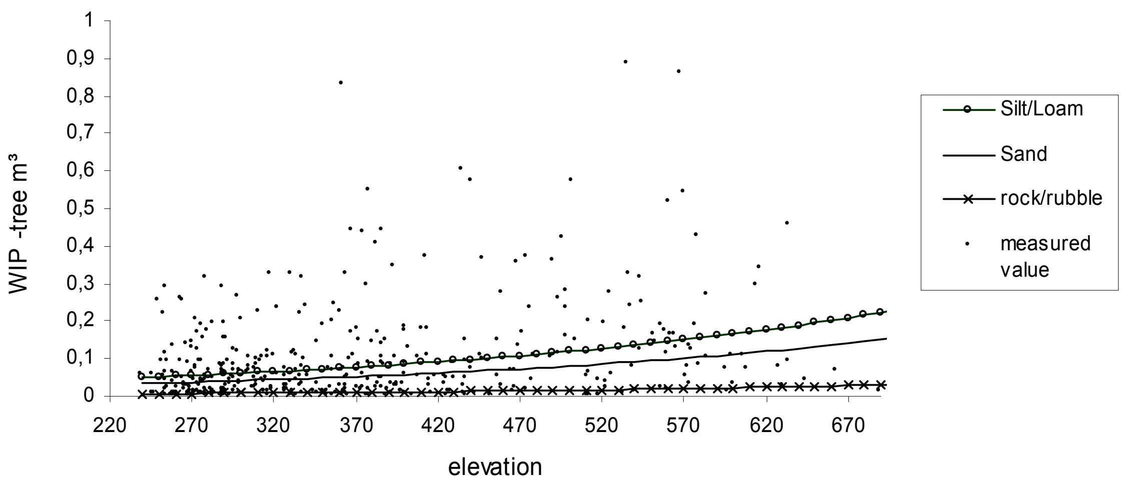

Fig 5.19: Wood volume of trees dependent on of soil texture and elevation

The reason for the relationship between the elevation and the wood volume were the taller trunks that the trees higher up the hillock had (table 5.46).

	Elevation in m				
	200-300	300-400	400-500	500-600	>600
Crown base (trunk length)	0.32	0.54	0.76	0.88	0.86

Tab. 5.46: Average crown base of trees among different elevations

The model did not give the same relationship for the crowns of the trees.

Crown volume index of trees (CV_P-tree)

Here the estimated value for the volume of the tree crowns increased with the depth of the soil and for different exposures but not for the elevation. Therefore it can be stated that the trees at the bottom of the hillock showed a more bushy form than the ones at the top.

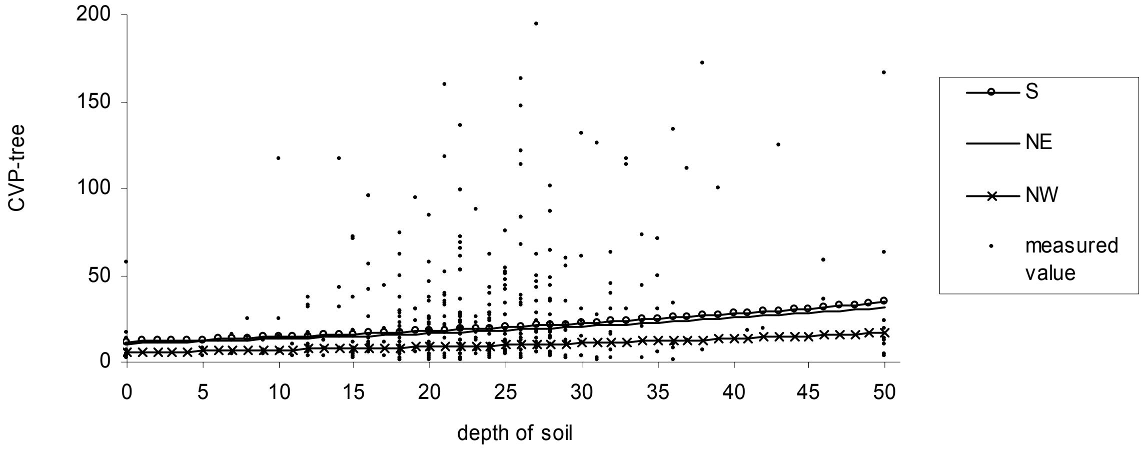

Fig 5.20: Crown volume of trees dependent on soil texture and exposure

The estimated values for an increasing crown volume showed only a small gradient. The difference between the estimated crown volume of the shallowest and the deepest soils for southern exposures was only 23.7 cm^3. Southern exposures are estimated to have the highest crown volume. The difference to the NE exposures was very small. This indicates a non-conformity between of the site and the tree cover. A low or depressed tree growth was expected on the site with the roughest conditions. The climate of the study area showed a high insolation. Therefore, the vitality of the site should be less on southern exposures. But the results showed exactly the opposite. The smallest volume was estimated for NW exposures. They are found in the areas where fires were recorded during the time of data collection.

Crown volume index of shrubs (CVP-shrubs)

For the volume of shrubs, the model estimated a smaller value on flat ground than on any exposure and a slight increase with higher elevation. The determining power was low as an absolute value, but relatively stronger for the exposure ($r^2 = 0.08$) than for the elevation ($r^2 = 0.02$).

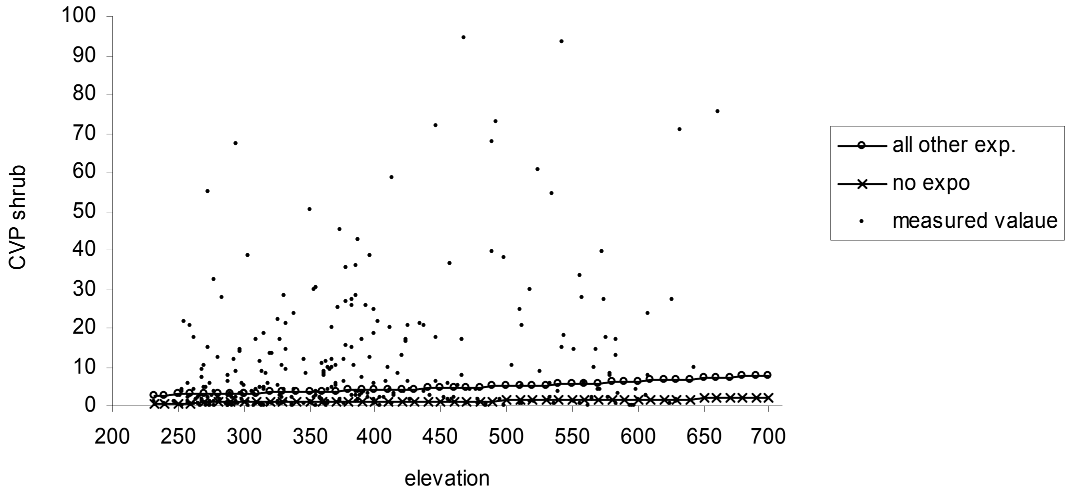

Fig. 5.21: Volume of shrubs dependent on soil texture and elevation

This was not a direct effect of the site. Flat areas are more readily accessible and are therefore more frequently utilised. An important factor seems to be the grazing. Because almost half of the plots with 0 exposure were placed in WS IV on lower elevations where the grazing pressure was high.

Biomass-index for subshrubs (SSV)

The site factors showed a relatively high r² for the volume of the subshrubs, based on the elevation and the exposure to almost equal parts (0.07 and 0.08 respectively).
The volume increased slightly with the elevation and thus the plants seemed to be better developed higher on the hillock.

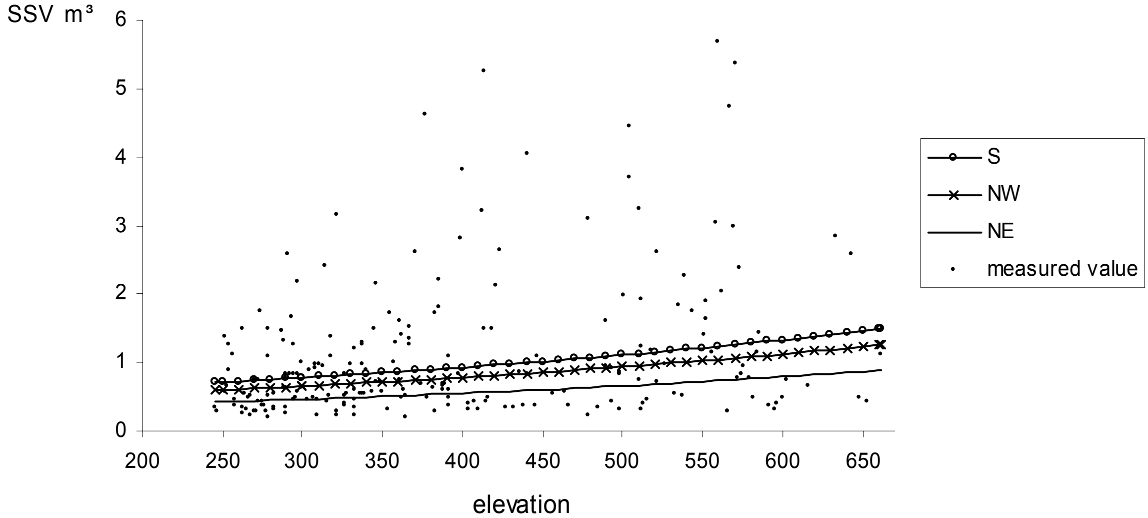

Fig. 5.22: Volume of the subshrubs dependent on exposure and elevation

The exposures with the highest insolation and dryness are recorded here with highest values.

Biomass index for grasses (GV)

With a r^2 of 0.19 the site shows the second best explanation for the volume of the grass layer. The main factor was the elevation followed by the soil texture. The fact that the volume increased with the elevation was due to an increasing grass cover higher up on the hillock (chapter 5.1.4.2) which resulted from the higher frequency of fires here. This effect was smaller on rock and on poorer soils (figure 5.23).

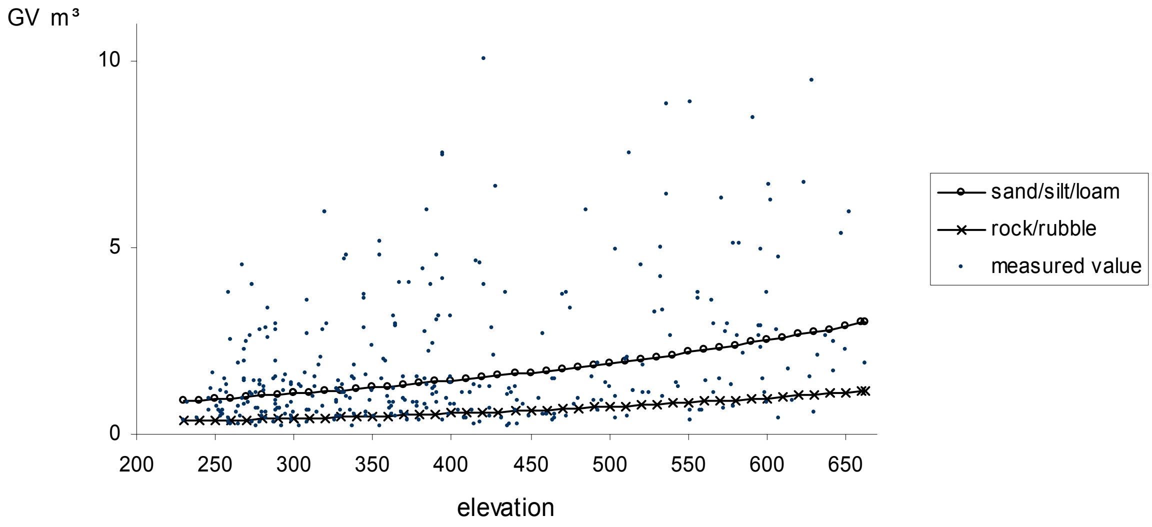

Fig. 5.23: Volume of the grass layer dependent on soil texture and elevation

For all tested parameters the influence of the site was small. If a correlation between the site and the vegetation exists in the model that was used, it is either an obvious one like the influence of the portion of rock on the cover with biomass, or due to human activity. This indicates that factors other than the site were responsible for the condition of the forest. In a further step this was tested with the watersheds as units with a different intensity of human impact.

5.3.2 Vegetation structure in dependent of human impact

To test the second hypothesis, the logistic and the linear regression were repeated. A new factor was integrated in addition to the site factors. This was the code for the different watersheds. The coding of the watersheds was done according to the intensity of fuelwood utilisation in the forest. This code separated the watersheds as well as the plots of the Temple Forest.
For a better understanding of the results the fuelwood collection intensity in the watersheds and there coding is presented again (figure 5.14 and table 4.11).

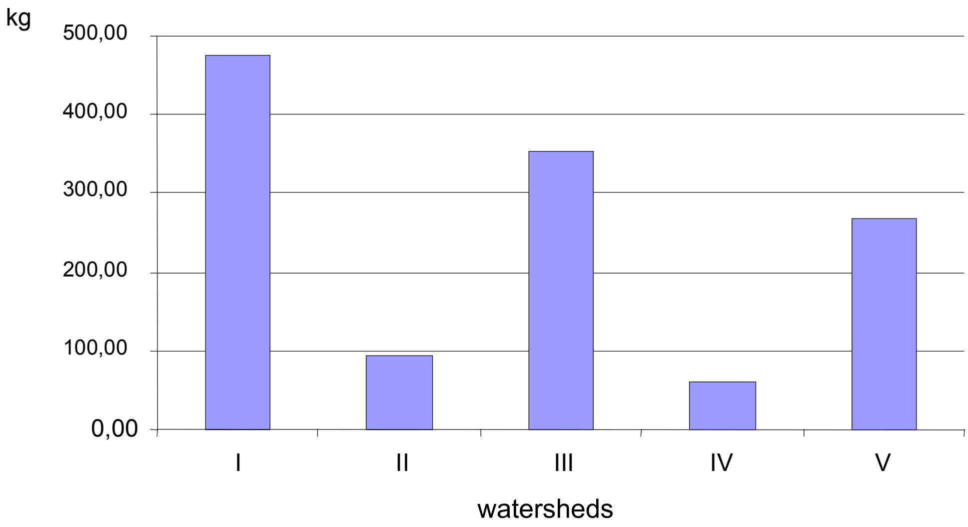

Fig. 5.14: Amount of fuelwood collected in the watersheds in kg/ha

Watershed	wo1	wo2	wo3	wo4	wo5
I	-2	-2	0	0	0
II	2	0	0	-1	-1
III	-2	1	-1	0	0
IV	2	0	0	1	-1
V	-2	1	1	0	0
Temple Forest	2	0	0	0	2

Tab. 4.11: Contrast coding of watershed

Wo5 separates the Temple Forest from the watersheds. It showed the lowest intensity of human impact.

5.3.2.1 Probability with which the vegetation parameters occurred

The following tables show, which factors were chosen to explain the probability of the presence or absence of the vegetation parameters after involvement of the new explanatory factor. The residual distribution did not change significantly.

Wood volume index of trees (WV_P-tree)

Regarding the wood volume of trees, none of the new parameters were selected. The results of this analysis are the same as in table 5.40, indicating that the probability of the occurrence of trees can only be explained based on of the small explanatory power of the elevation.

Crown volume index of shrubs (CV_P-shrubs)

As table 5.47 shows, the model chose the watershed-variables wo5 and wo3. Wo5 and wo3 distinguish the three most used watersheds I/III/V, the two less frequented ones WS II and IV and the Temple Forest. The results of the function given by the logistic model implemented in the function of probability (formula 12) gave the highest probability of shrub occurrence for the Temple Forest followed by WS I and III. The lowest probability was given for WS V. Assuming that the result for the Temple Forest was caused by the low number of plots, it could be stated, that a high frequency of fire and/or fuelwood cutting led to a higher probability of shrubs presents. But due to the low explanation power this can not be taken as a strong reference.

Explanatory variable (x)	Sequence of affiliation	Parameter		Significance	-2-Log-Likelihood-value after affiliation
Intercept		b_o	0.3318	0.2609	662
so1	1	b_1	0.03523	0.0019	635
eo2	2	b_2	-0.3350	0.0016	623
wo5	3	b_3	0.3950	0.087	617
Cover of rock	4	b_4	-0.00857	0.0481	615
eo1	5	b_5	-0.0968	0.1157	612
wo3	6	b_6	-0.2153	0.1310	610

Tab. 5.47: Parameters of the Logit-function for estimation of the non-zero value probability of the crown volume index for shrubs after including the watersheds

Biomass index for subshrubs (SSV)

The depth of soil holds the highest explanatory power also for the probability of the presence of subshrubs, followed by wo2.
The selection of wo2 as a significant factor indicates the highest probability of the presence of subshrubs in WS III and V and the lowest in WS I. WS III was the watershed where subshrubs were utilised most.

Explanatory variable (x)	Sequence of affiliation	Parameter		Significance	-2-Log-Likelihood-value after affiliation
Intercept		b_o	-1.5772	0.0001	690
depth of soil	1	b_1	0.0261	0.0180	678
wo2	2	b_2	0.2615	0.0106	671
so1	3	b_3	0.3102	0.0160	665
eo2	4	b_4	0.1615	0.1140	661

Tab. 5.48: Parameter of the Logit-function for estimation of the non- zero value probability of the biomass index for subshrubs after including the watersheds

Biomass index for grass (GV)

Depth of soil and the watershed-variables replace the exposure and the elevation as the most important site factors of the first analysis (table 5.49). The model showed the depth of soil as the highest explanatory power. The negative parameter indicated a lower probability of finding grasses with increasing soil depth. As figure 5.20 showed, the crown volume of the trees increased slightly on deeper soil. This could be the reason why the probability of grasses occurring here was smaller. It was noticed that the correlation between grass probability and soil depth without the implementation of the watershed-variables was positive but with a low explanatory power (table 5.43). The inclusion of the watershed-variables led to a negative parameter with a much higher explanatory power. This seems to be caused by the difference in the tree crown volume in the various watersheds. They showed the second highest explanatory power for the probability of grass occurrence. The coding and the results of table 5.49 sorts the watersheds in the following order for the probability of grass occurrence $(w_i)^2$: WS I (0.09), II/IV (0.02), III/V (0.02) and the Temple Forest (0.003). This means, that there was high chance of finding grass in WS I while the probability of finding grass in the other watersheds was relatively small.

Explanatory variable (x)	Sequence of affiliation	Parameter		Significance	-2-Log-Likelihood-value after affiliation
Intercept		b_o	-1.6548	0.0025	637
Depth of soil	1	b_1	-0.0376	0.0029	604
wo1	2	b_2	-0.2710	0.0012	600
wo5	3	b_3	-0.6255	0.0310	594
wo2	4	b_4	-0.484	0.0019	590
Elevation	5	b_5	0.00280	0.0057	585
so3	6	b_6	-0.1925	0.0317	582
so2	7	b_7	1.0954	0.0337	579
so4	8	b_8	-0.2717	0.1219	577

Tab. 5.49: Parameters of the Logit-function for estimation of the non-zero value probability of the biomass index for the grass layer after including the watersheds

Success of classification

Changes in the estimation by the model if a parameter was present or not occurred only for the parameters where one or more of the new explanatory variables were selected.
This was not the case for the wood volume of trees. For the parameters where a change occurred, the variable was negligibly small. The model estimated the presence of a non-zero value in most cases, even when a zero-value occurred. A change of the threshold classification from 0.5 to 0.8 did not lead to a better classification and sometimes altered the ratio of estimated cases completely.

Analysed parameter	Parameter present	Number of observed events	Estimated number of events at a critical probability value of 0.5		0.8	
			Present		Present	
			yes	**no**	**yes**	**no**
WV_P-tree	**yes**	407	401	6	293	114
	no	101	99	2	43	58
CV_P-shrub	**yes**	327	310	17	53	274
	no	181	143	38	10	171
GV	**yes**	345	323	22	97	248
	no	163	126	37	23	140
SSV	**yes**	213	69	144	0	213
	no	295	52	243	0	295

Tab.5.50: Observed and estimated number of plots for zero and non zero value at different threshold probabilities after including the watersheds

It can be said that the logistic regression does not show a clear influence of the different utilisation intensities in the watersheds on the vegetation parameters. Even if the watersheds are selected as explanatory variables, their influence is not strong. Striking is that the clearest results were given by the model for the grass cover. This parameter is closely related to the forest fires.

[2] See formula 12

5.3.2.2 Influence of the human impact on the vegetation

The five watersheds and the Temple Forest were also analysed by means of linear regression. The next table gives the parameters and r² for this analysis (table 5.51).

Independent variable (x)		Dependent Variable					
		% Cover biomass	WV_P-trees	CV_P-tree	CV_P-shrub	Subshrub volume (SSV)	Grass volume (GV)
Intercept	b_0	3.77858009	-4.42492052	2.42309487	-1.15836943	-0.06645502	-1.01462513
Elevation	b_1	0.00047003	0.00335468	/	0.00202540	0.00307141	0.00301752
	r^2	0.03	0.06	/	0.07	0.03	0.12
Slope	b_2	/	/	/	/	/	/
	r^2	/	/	/	/	/	/
Depth of soil	b_3	/	/	0.03048422	/	/	/
	r^2	/	/	0.05	/	/	/
Cover of rock	b_4	-0.00473115	/	/	/	/	/
	r^2	0.08	/	/	/	/	/
so1	b_5	0.21224255	0.35748207	/	/	/	0.16882384
	r^2	0.43	0.05	/	/	/	0.02
so2	b_6	0.24501462	/	/	/	/	/
	r^2	0.01	/	/	/	/	/
so3	b_7	/	0.12482922	/	/	/	/
	r^2	/	0.02	/	/	/	/
so4	b	/	/	0.49162016	/	/	/
	r^2	/	/	0.02	/	/	/
eo1	b_9	-0.03035938	/		/	-0.31721848	/
	r^2	0.01	/		/	0.08	/
eo2	b_{10}	/	/	0.16672180	/	/	/
	r^2	/	/	0.01	/	/	/
eo3	b_{11}	/	/	/	/	/	/
	r^2	/	/	/	/	/	/
eo4	b_{12}	/	/	/	/	/	-0.24962704
	r^2	/	/	/	/	/	0.03
wo1	b_{13}	/	0.18264562	0.18790751	/	/	/
	r^2	/	0.01	0.05	/	/	/
wo2	b_{14}	/	/	/	0.17712698	/	/
	r^2	/	/	/	0.02	/	/
wo3	b_{15}	0.06192099	0.18968331	0.26696685	/	0.59705150	0.48297924
	r^2	0.01	0.01	0.03	/	0.06	0.09
wo4	b_{16}	0.06561425	/	/	0.35332426	0.41828419	0.18042905
	r^2	0.01	/	/	0.07	0.02	0.01
wo5	b_{17}	0.10115762	0.49493789	0.69492529	/	/	0.44863782
	r^2	0.01	0.02	0.02	/	/	0.06
Sum WS	r^2	0.03	0.04	0.10	0.09	0.08	0.16
Sum	r^2	0.56	0.17	0.18	016	0.19	0.33

Tab.5.51: Parameter (b) and partial r² for the determination of the vegetation parameters through the Watersheds and the site factors

The watershed-variables were significant regarding all other analysed vegetation parameters. The determining power was generally similar to that of the site factors and varies among the different parameters.

Cover with Biomass

The watersheds showed the lowest explanatory power for the biomass coverage. It did not really correlate with the different degrees of human impact. It is obvious, that the Temple Forest had the thickest vegetation and showed the highest values. The differences were small among the watersheds. This indicates that the different uses, including fire, did not lead to a loss of vegetation in general.

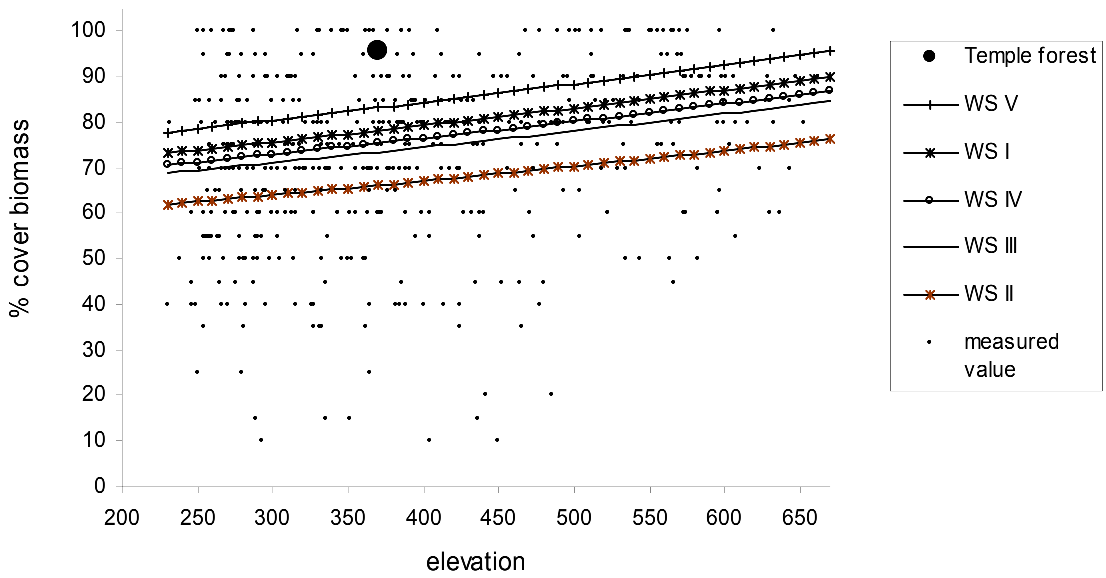

Fig 5.24: % of cover of biomass in dependent on watersheds and elevation

Wood volume index of trees (WV_P-tree)

Regarding the wood volume the model clearly calculated the highest values for the less disturbed vegetation of the Temple Forest. Comparing the differences between the values of the Temple Forest and the watersheds, the latter could be seen as one category of disturbance.

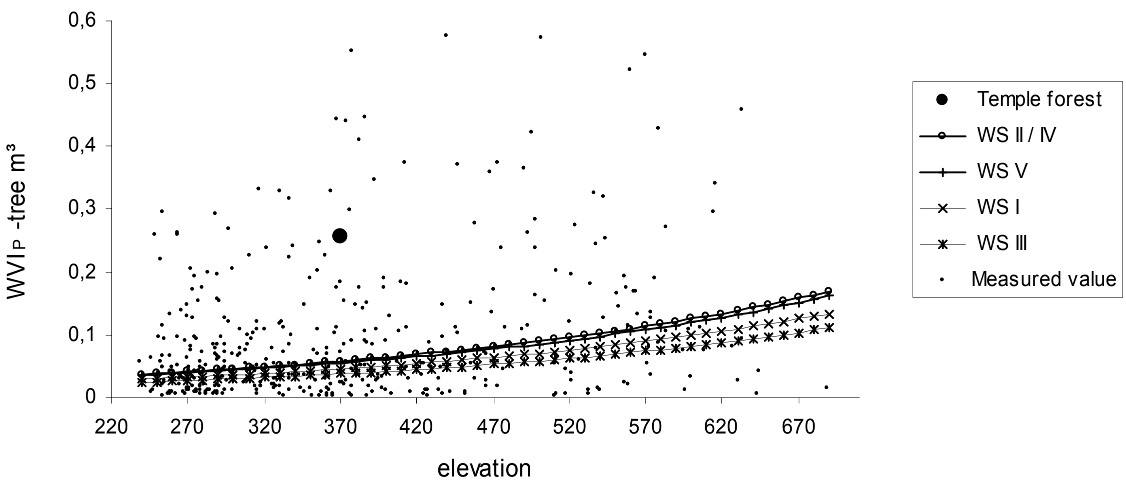

Fig 5.25: Wood volume of trees dependent on watersheds and elevation

The differences between the watersheds indicate the influence of the utilisation of trees. WS I, III and V were the watersheds with the highest utilisation of fuelwood. WS I and III were estimated by the model to have the lowest wood volume. The values given for WS V are relatively high (see also table 5.4).
The weakness of this correlation is not only indicated by the difference between the result of the regression and the average value but also by the small r^2 for the watersheds regarding the wood volume of 0.04.

Crown volume index of trees (CV_P-tree)

For the crown volume the model showed a relatively high explanatory power of watershed-variables. Similar to the wood volume, the highest values were estimated for the Temple Forest. In contrast the model clearly distinguishes the wood between WS V and the other watersheds. This matched the ranking of the average values for the watersheds, where WS V also had the highest value (table 5.4). The difference between the estimated values for the other watersheds was small. WS III showed the smallest values.

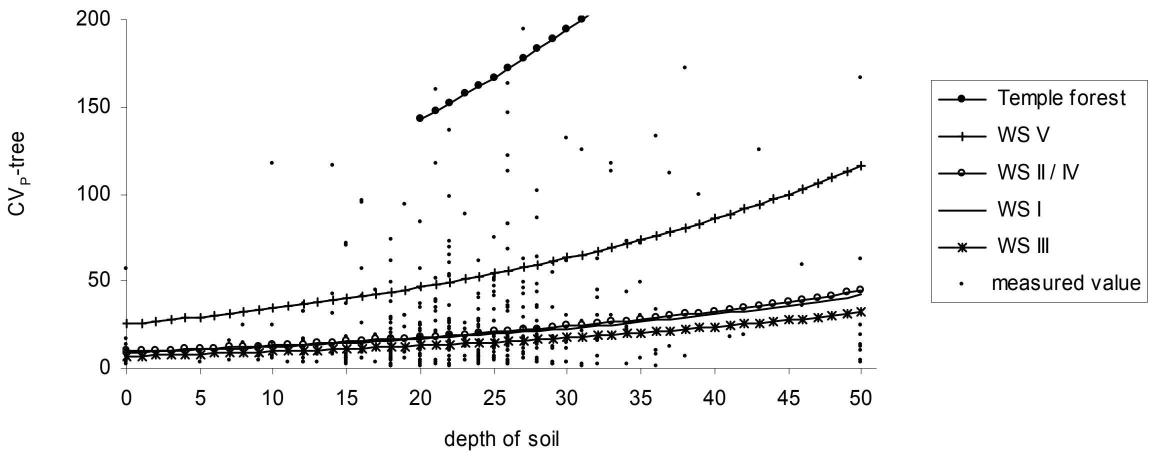

Fig 5.26: Crown volume of trees dependent on watersheds and soil depth

With the integration of the watershed-variables the model reduced the significance of the exposure. This was partially explained by the dominance of some exposures in certain watersheds. Most of the plots with NW exposures were found in WS III and southern exposures dominate in WS IV.

Crown volume index of shrubs (CV_P-shrubs)

The crown volumes of shrubs are explained more clearly by the watershed-variables. The influence of the altitude and the exposure almost do not change after the integration of the watershed-variables as explanatory factors.

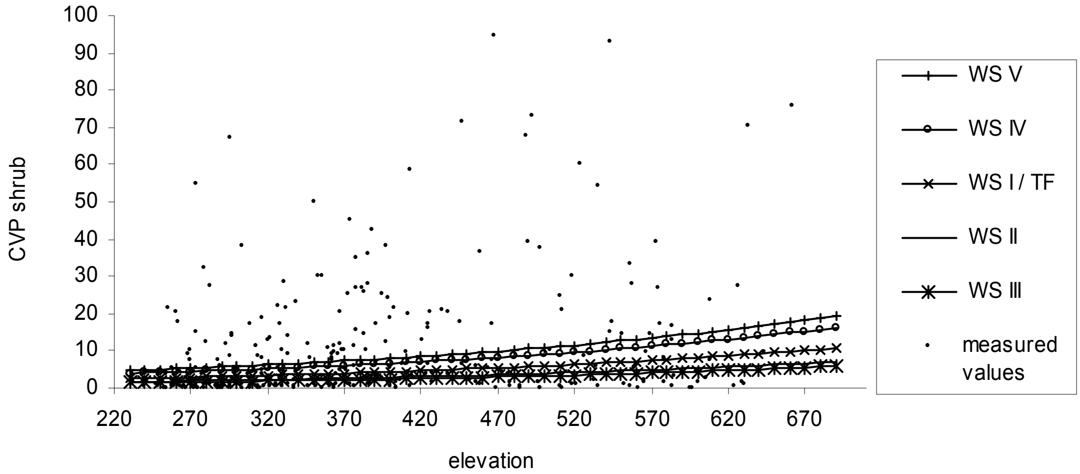

Fig 5.27: Crown volume of shrubs dependent on watersheds and elevation (TF = Temple Forest)

The smallest shrubs were found in the watersheds with a higher fire frequency. The main shrub species can establish on open areas and develop depending on the fire frequency. In WS I, II and III the shrubs had a relatively poor development. Their volume was regularly reduced by fires and in WS I and III by fuelwood collection as well. The Temple Forest also only had small shrubs. Here the reason was not the influence of fire but the dominance of the trees. WS IV had small shrubs compared with WS V. This could be a result of the absence of open areas where shrubs could develop.

Biomass-index for subshrubs (SSV)

The watersheds with a r^2 of 0.09 for the volume of subshrubs had the highest determining power. The model estimates the highest values for WS IV followed by WS III and V.

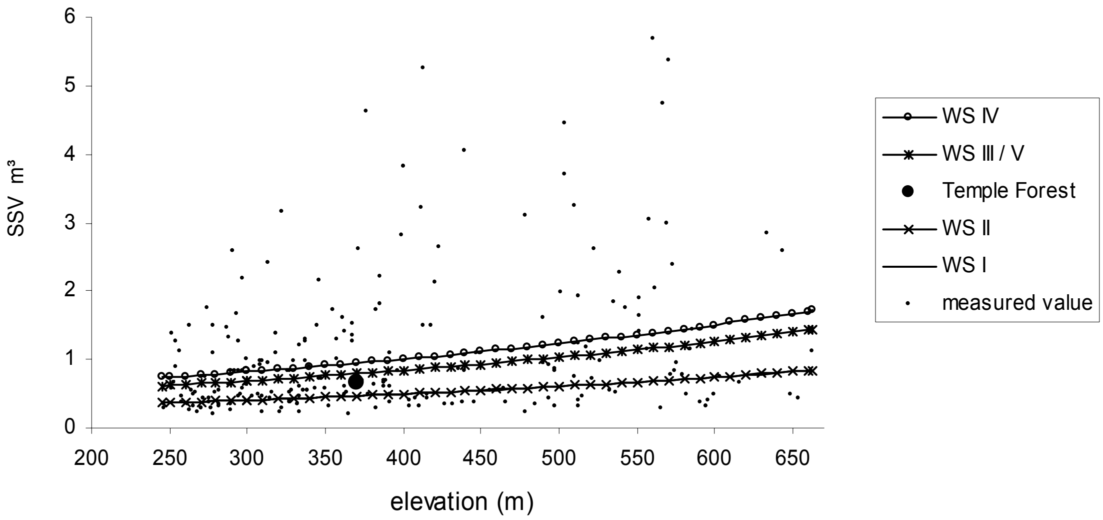

Fig 5.28: Volume of subshrubs dependent on watersheds and elevation

The estimation of the model was not based on the watersheds alone but also on the influence of the elevation. This led to slightly different results compared to the descriptive analysis. Due to a higher subshrub volume in the lower parts of WS IV, the model generally estimates higher values for WS IV (table 5.52).

	Watersheds				
	I	II	III	IV	V
Volume in m³ < 500 m	0.52	0.51	0.85	1.23	0.99

Tab.5.52: Average volume of subshrubs below 500 meter elevation

The model estimated a relatively high volume of subshrubs for the Temple Forest. This is due to the small number of plots. Only one plot contained subshrubs but with a volume above the average of those in the watersheds.

Biomass index for grasses (GV)

The frequency and amount of grasses is another factor indicating the extent of the influence of fire. In chapter 5.1.4.2 it became clear that WS I had the highest ratio of plots containing grasses followed by WS II, III and V. These are the watersheds, where the fires were observed during the time of data collection. WS IV had grasses in only half of its plots and also the lowest coverage rate. The volume of the grass layer follows different patterns (figure 5.29).

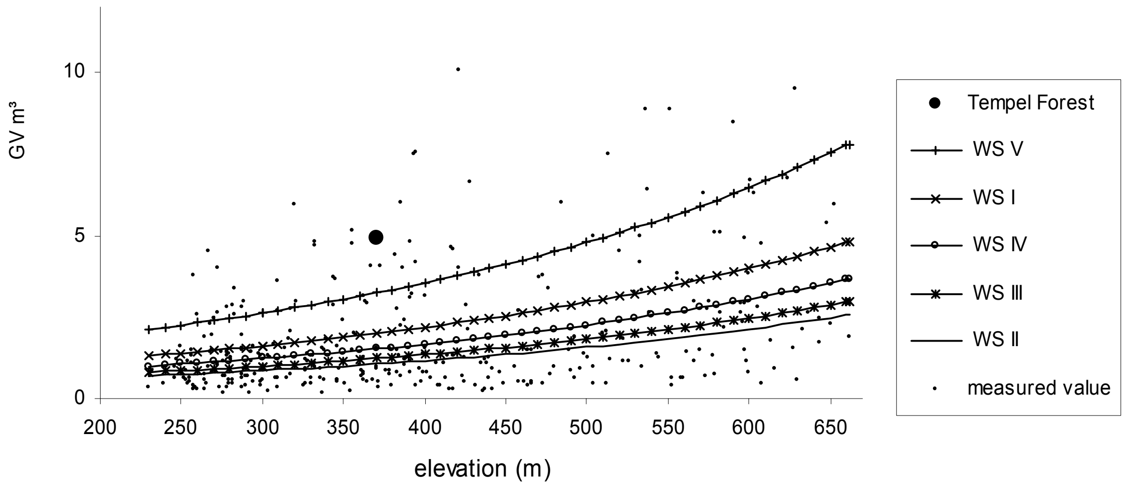

Fig 5.29: Volume of grass layer dependent on watersheds and elevation

The plots with the lowest fire frequency among the watersheds where fires could be observed showed the highest grass volume. The reason is a low fire frequency causing a grass layer to build up a relatively huge biomass until the next fire. In the Temple Forest this lead to an estimation of the highest values. Two plots where there had been fire some years ago showed a grass volume of 4.0 and 2.7 m³ respectively. Among the watersheds, WS V clearly had the highest volume. Fires occurred here but only on small spots and less frequent than in WS I and II. The average grass volume of the latter was small because of the fire event during the data collection. The model estimates a fairly high value for WS IV. That is another indicator that fire appears there even if no fire could be observed during the project period. The explanatory power of the watershed-variables was highest for the grass volume with an r^2 of 0.16.

The results of the second analysis denote an influence of the watersheds on the vegetation of the Reserved Forest. Except for the wood volume, the vegetation varies such that the differences according to the usage can be detected. This connection between the vegetation and its attribution to different intensities and types of utilisation was hinted at but was not overwhelming. The reason cannot only be found in an overlapping of the different usage systems but is also due to an influence which shapes the vegetation of the Kadavakurichi Forest more intensively than all others: the forest fires.

6 Discussion

The previous chapters draw a picture of the state of the forest and its use in the study area. It is clear that the forest utilisation of today keeps the forest in a degraded stage far from the potential growth. The object was to explain the effects of different grades of human impact on the vegetation in order to point out solutions for change. In this chapter the applied methodology, the state of the forest and the factors playing a role in its utilisation shall be discussed focusing on the framework needed for change.

6.1 Critical assessment of the methodology

6.1.1 Vegetation survey of the Kadavakurichi RF

The Kadavakurichi RF covers an area of 10 km² and was surveyed with 500 plots. A size of 30 and 9 m² was selected for trees and other phenotypes respectively. The plot size had to be kept small in order to demarcate a sufficient number of plots to represent the vegetation of the different watersheds. According to VRIES (1986) and KRAMER & AKCA (1987) the size of a sampling plot in forest inventory usually depends on the homogeneity of the stand. The more heterogeneous a stand is, the larger the sample plot should be. Similar rules apply for a floristic classification. In order to describe vegetation formations floristically, each formation must be homogeneous (MUELLER-DOMBOIS & ELLENBERG 1974, DIERSCHKE 1994 and FISCHER 1995) and a sample plot should represent the floristic composition of the described vegetation type (FISCHER 1995).

The aim of the vegetation survey focused primarily on the description of the vegetation composition as well as the structure of the entire forest including the watersheds and not on the plant communities found on the hillock. According to MUELLER-DOMBOIS & ELLENBERG (1974) quadrates or point samples can be spread over a vegetation segment if "the emphasis is on sampling the quantitative variation of species within large communities defined only by dominant species" (p. 47). In this case, many smaller sampling plots instead of a few big ones were used.

Temporary plots were chosen to fulfil the aim of the vegetation survey to describe the actual vegetation. To analyse the development of the forest over a period of time, the vegetation survey should be repeated if changes in kind and intensity of use take place. For an acquisition and analysis of such temporal transitions PFADENHAUER et al. (1986) consider a grid of permanent plots to be necessary. Two main reasons speak against the installation of such a design: Firstly, it is very uncertain that a repetition of the study will be done and the effort necessary for the installation of permanent plots would therefore be inappropriate.

Secondly, the error of the measurements in the different plots in one unit (watershed) increases, if the values of the measurements at the beginning of the observed time period (x) and the end (y) show a weak or no correlation. The standard error for such a measurement is shown by formula 14:

$$s_{\bar{y}-\bar{x}} = \sqrt{s_{\bar{x}}^{\,2} + s_{\bar{y}}^{\,2} - 2 \cdot r \cdot s_{\bar{x}} \cdot s_{\bar{y}}} \qquad (14)$$

s = standard error, x = value at the beginning of the observed time period, y = value at the end of the observed time period, r = correlation coefficient

If an exclusion of the human impact on all plots of one watershed is assumed, a similar development in all plots would take place and the value y-x would correlate among the plots. Thus r would increase and the error decrease. In such a case a permanent plot system would be suitable. Such development cannot be expected in the studied area as a permanent plot system would lead to a similar error compared to a temporary plot system. This would have made a permanent plot system ineffective. Should a clear change take place and lead to a distinct differently vegetation formation, a repetition of the survey using temporary plots would be expected to confirm this.

In such a survey, measurement efforts should be reduced. It would for example be enough to estimate the crown projection at the base of a limited number of individual trees as reference instead of measuring every one. The way the trees are damaged makes it unlikely to create a regression model that estimates the crown projection on the basis of another parameter such as the diameter at root collar. In this case the estimation of some of the trees has to be proved through measurement until a sufficient number of measurements are made.

A plot installation that functions without the installation of four single ropes would also save a lot of time. The application of sub ropes was found to be disproportional and should be eliminated from further studies.

The system used to locate the plots was very difficult and exhausting. A satellite supported navigation system (GPS) would have allowed for much more comfortable field work. The lack of financial resources did not permit such equipment, but it is highly recommended to use these techniques in similar studies, especially in thorny forest types.

6.1.2 Socio-economic survey

The selection of the user households for the interviews was one of the central points in raising the information about the forest use. By involving the PHCC staff in charge of the village it was possible to get good and concise information about the forest uses. This allowed the comparison of the watersheds and conclusions for the entire population. The different social positions that the PHCC workers in the villages had, were an uncertainty. Some were from the villages where they helped to find the user households, while others were not. Therefore the available information on the different villages was not always exactly the same. Compensation through the involvement of other village inhabitants was attempted but it was not possible to conduct this in exactly the same way in every village. Participatory Rural Appraisal (PRA) methods could not be employed because of the available time and the need of a multidisciplinary research team (SCHÖNHUT & KIEVELITZ 1993).

One way to improve the knowledge of the impact on the different watersheds would have been a footpath survey using face to face interview with the forest dwellers in the forest itself. Such a study would have to be carried out on several days distributed over some weeks. In 1992, the PHCC found 43 entry points in the Kadavakurichi. If only half were to be surveyed several people would have had to be employed, trained and transported. This was beyond the scope of this study. The data raised during footpath surveys by the PHCC in recent years did not allow for a reliable analysis.

6.1.3 Linking human influence and vegetation structure

In order to examine the influence of the forest utilisation on the vegetation, data on forest use and the forest structure was gained according to the watersheds. Thus the collected data referred to a wide area of the forest and could not provide information for a single plot. This made the exact evaluation of use and vegetation formation impossible. To solve this problem, a way had to be found to determine the influences on a single plot.
The results of the present study show that the intensity and ratio of the signs of damage could not determine the intensity of utilisation. Also plots containing only grasses resulting from fires did not show any signs of fire. Similarly trees of retarded growth after being used for fuelwood collection no longer showed the signs of cutting. It now seems reasonable to use such vegetation parameters to explain the vegetation resulting from use. For example a high ratio of grass-cover could be a sign for a high fire frequency and a bushy growth of trees a sign for fuelwood collection. Then these parameters would be both the explaining and explained factors. That makes no sense.
It is therefore more necessary to know the impact on each plot, independent of the vegetation structure it shows. To solve this problem the information on the treatment of a uniform structured stand must be available. KHATTAK (1992), KOTRU (1993) and GIESCH (2000) raised indicators of human impact on the vegetation in subjectively selected stands under different grades of influence. On the strength of this information they combined the human impact with the forest structure. This method presumes that the treatment of the stand is known. Also such information should be based on long term observations in order to cover all influences (external users, fire). But this involves a tremendous effort, even for a limited number of units. In the case of fuelwood collection and grazing it would be necessary to constantly collect data about the rate at which the selected vegetation segment is frequented and the intensity with which it is used. The object of observation should then be the use itself and the signs of use, which because of being recent could be estimated to give a good picture.
It is far more important to know more about the fire and its influence on the vegetation. The fires can turn up at quite long time intervals and therewith a long-term observation is also needed here. This could be done in the described manner for fuelwood collection and grazing. But it would take less effort, if instruments could be installed which record each occurring fire. These instruments have to be such that do not attract passers-by, who could collect them or animals, which could harm them. If it were possible to record every fire, the fire frequency for different vegetation types could be noted together with its influence on the vegetation. On the base of this information unreal time series of the vegetation development under different intensities could be conducted.
Plots where the influence is permanently excluded would surely be of great help. But these plots need besides the long term observation, a constant maintenance (BELLEFONTAINE et al. 2000) which is often difficult to realise.
A method requiring less effort is to refer to the available literature about the change in the vegetation under different types and intensities of use. But the information in the literature that could be found was not precise enough to allow the conclusion of uses in the required way, least of all not for the single plots.

Regarding the statistical analysis, one could doubt whether the correct model was chosen, and if it was targeted to exclude the plots with zero value for the tested parameter from the linear regression. An analysis including all plots was done, but no useful results were obtained. Another way would have been to analyse the data for each watershed separately. But this would not have involved all site aspects in the calculation and would therefore have excluded available information. It is likely that another statistical procedure could have given the same results. For a long time the human impact on the forest has been so intensive that it overrides the influence of the site.

6.2 The vegetation of the Kadavakurichi and its characteristic

Before the actual vegetation and the reasons for its formation can be discussed, the potential of the site should be considered. To know the forest type that could exist on the Kadavakurichi a reference site with none or a low human impact is needed. The only such reference for the Kadavakurichi is the little Temple Forest in watershed V.

6.2.1 Potential growth

For the development of a management system providing exact figures about the sustainably utilised amount of forest products, the necessary information about the growing rate is lacking. BELLEFONTAINE et al. (2000) point out that it is generally difficult to get the information for dry tropical forest. They refer to different authors, who give for dry forests in West Africa with an annual precipitation similar to in the study area a growth rate between 0.5 and 0.6 m^3 ha^{-1} a^{-1}, which varies strongly between the different areas.

The growth rate of 0.41 m^3 year ha^{-1} given by LAL (1992) and SINGH (1992) for the dry Indus plains originate from another geographical area and even if they are said to represent protected forest, they cannot be taken as valid for pristine forests. To raise such data from plantations is difficult because they do not exist long enough to give a picture of the dimensions the trees can reach. The size of the four big trees in the Temple Forest and the reported extraction of high value timber in the last centuries (FRANCIS 1906 and BOOMGAARD 1998) indicate that these sites can produce valuable timber in considerable dimensions. But it is not clear how long this takes. There are no sites or data with which to compare the growth of the four temple trees in order to estimate the time required to reach these dimensions. And it is also not clear, how long it would take for the main species of the Kadavakurichi, *Commiphora berryi* and *Euphorbia antiquorum* to grow to the dimensions they show at present.

According to BELLEFONTAINE et al. (2000) annual growth marks exist in all species, “but for the most, they are either not at all visible or not easily visible to the naked eye.” (p. 101). It is likely that *Commiphora berryi* falls into the first group. About this species no detailed information could be found, but BELLEFONTAINE et al. (2000) mentioned *Commiphora africana* as a species that has no visible growth rings. However, to determine the age of the trees in the study area which show annual marks in the wood would be possible, but the methods that exist to identify the age of tropical wood (LAMPRECHT 1986) require a high effort. They could not be conducted in the frame of this study but these methods may be helpful and should be used for the future in raising data to determine the growth rate.

6.2.2 Plant sociological classification

Because detailed studies about the vegetation in the dry parts of the Tamil Nadu plains are extremely rare, the plant sociological classification of the studied forest shall be intensively discussed here. None of the references used here dealing with vegetation classification in South India contain classical species lists for the forest types coming in consideration for the vegetation of the Kadavakurichi. The species compositions have in most cases a descriptive character and therewith a table comparing the different species lists can not be created here.

6.2.2.1 Climax vegetation

The lack of information about the climax vegetation makes it difficult to state the composition of the tree species that occur on the Kadavakurichi. It is doubtful that a plant sociological classification of the species found in the Temple Forest can be a valid base for reflection about the climax vegetation because the temples in India have a long tradition of religiously motivated tree planting (CHANDRAKANTH et al 1990). There is no literature available about the trees preferred for planting in Temple Forests in the region of the study area. None of the species used for planting in Indian temple forests listed by CHANDRAKANTH et al. (1990) occur in the Temple Forest of the KV. From its placement directly beside the temple and the numerous bells hanging on it, one can deduce that at least one of the *Azadirachta indica* trees was planted. The big *Acacia leucophloea* and *Drypetes sepiaria* seem to be a remnant from previous vegetation. The latter was mentioned as part of the Dry Evergreen Forest from MEHER-HOMJI (1974) and BLASCO & LEGRIS (1973). More common species like *Lepisanthes tetraphylla*, *Atalantia monophylla* and *Diospyros ebenum* are found in Dry Evergreen Forests of the Coromandel coast (PARTHASARATHY & KARTHIKEYAN 1997). In their general description of the Dry Evergreen Forest CHAMPION & SETH (1968) list *Drypetes sepiaria* and *Diospyros ebenum.* Other species of the Temple Forest such as *Sapindus emarginata*, *Albizia amara* and *Atalantia monophylla* are listed for Dry Evergreen Forest types in Andhra Pradesh. This supports the attribution of the Temple Forest to a Dry Evergreen Forest type.

6.2.2.2 The present vegetation

Whatever the climax was, not much is left anymore. The Kadavakurichi today bears a bushy vegetation of thorny woody plants that alternates with open grasslands. Trees occurring in almost all surveyed plots have an average height of not even 2 meters. With an average tree cover of 31% it falls in the category of “open forests” according to the definition set by the GOVERNMENT OF INDIA (1999) as 10-40% crown density. The low wood volume, the low inserted and small crowns, the multi-stemmed trunks, the clumsy form and small diameter at breast height of the trees are indicators of degradation. The composition of the species found in Kadavakurichi RF also indicates degraded vegetation. The species are part of some of the forest types that CHAMPION & SETH (1968) classify as degraded stages of the Southern Dry Deciduous Forest and for the Southern Tropical

Thorn Forest[1]. But in all cases the most frequent tree species *Commiphora berryi* is missing.
According to CHAMPION & SETH (1968) one of the degraded forms of the Dry Deciduous Forest is the Dry Deciduous Scrub. A special type is not given for the southern Indian peninsular. The greatest similarity to the floristic composition of the study area is found in the formation of the southern Mysore plateau. This is the only type that occasionally contains a *Commiphora* species that one can estimate to be *Commiphora berryi*. Other species of this type found in the study area are: *Euphorbia antiquorum*, *Dichrostachys cinerea*, *Albizia amara*, *Chloroxylon swietenia, Commiphora caudata* and *Ziziphus oenoplia.*
The grass layer shows a high floristic similarity to the Dry Grasslands, another degraded stage of the Tropical Dry Deciduous Forest in the CHAMPION & SETH (1968) classification. *Chrysopogon fulvus* and *Heteropogon contortus* occur in this type, while *Themeda cymbaria*, the second most frequent grass species, is not listed. According to MATTHEW (1991) this species exists in the west of the Indian peninsular. BLASCO (1971) in his description of the steppic vegetation of Tamil Nadu places *Themeda cymbaria* above 700-900 meters. But on the Kadavakurichi it dominates the regularly burned fields starting already at an elevation of 400 meters. This indicates that the presence of this species in the study area is determined more through fire and human impact rather than through the altitude. But a connection between the influence of fire and *Themeda cymbaria* could not be found in the literature.
Another degraded form of the Dry Tropical Forest is the Euphorbia Scrub, which can also result from the degradation of the Thorn Forest. The form CHAMPION & SETH (1968) give for the dry plain regions in Tamil Nadu (Madras) only includes a few tree species. *Euphorbia* as the dominant genus was mainly represented by the tree species *Euphorbia antiquorum* and *E. tirucalli*. Only two of the listed shrub species are found in the studied forest and none of the given grasses. It can be surmised that this type represents a further stage in degradation than that of the forest on the Kadavakurichi.
The Southern Thorn Forest under the "usual maltreatment" turns into the Southern Thorn Scrub, "a formation of close, almost impenetrable thorny thickets…" (p. 233) and shows a height of 4-6 m. Here the tree layer is richer in species and they are all represented in the Kadavakurichi RF: *Albizia amara*, *Azadirachta indica*, *Chloroxylon swietenia* and *Wrightia tinctoria*. Also all species except *Securinega leucopyrus* of the shrub layer are represented in the forest studied. Therefore the Southern Thorn Scrub appears to be closer to the vegetation of the Kadavakurichi in formation and species composition, even if the height and the density indicate a lower grade of disturbance.
The fact that *Euphorbia antiquorum* and other *Euphorbia* species are often mentioned in connection with degradation and *Commiphora berryi* is excluded, fits the observation of the vegetation on the southern slope of the lower Palni Hills and the surrounding hillocks, where the former occurs almost regularly and the latter irregularly.
In the classification of CHAMPION & SETH (1968) the Kadavakurichi RF could be placed between the Southern Thorn Scrub and the Southern Euphorbia Scrub owing to the large portion of *Euphorbia antiquorum* while the low average height of the forest tends towards the latter.

[1] An extraction of the important vegetation types from the classification of CHAMPION & SETH (1968) for the study area is given in appendix 3.2

The types and sub-types of the Dry Tropical Deciduous Forest of MEHER-HOMJI (1977) do not show an obvious similarity in the floristic composition with the studied forest. Only in the miscellaneous sub types is *Euphorbia antiquorum* mentioned with another *Commiphora* species, *Commiphora mukul*. The first is given as an understorey tree of the *Hardwickia binata* sub type while the second occurs in the undergrowth of the *Anogeissus pendula* sub type.
MEHER-HOMJI (1977) also mentioned *Commiphora mukul* as part of the degraded vegetation of the *Anogeissus pendula* sub type on hillocks. The other plants of this type, like *Anogeissus pendula* (occurring in a shrubby form) *Euphorbia caducifolia*, *Wrightia tinctoria*, *Grewia tenax*, *G. villosa*, fit only partially to the vegetation of the study area.

A few references mentioned *Commiphora berryi* and *Euphorbia antiquorum* together. One is GEORGE & VARGHESE (1985), who describe a Dry Deciduous Forest near Coimbatore (Mudumalai Wild Life Sanctuary), an area of less than 750 mm annual rainfall. This forest can be assumed to be less degraded. The two species occur here as understorey trees.
Another example is MEHER-HOMJI (1974) who listed *Euphorbia antiquorum* and *Commiphora berryi* together as characteristic species[2] of the Dry Evergreen Forest. The former for the Dry Evergreen Forest of South India and the latter for the whole of India. This is striking, because *Commiphora berryi* is not an evergreen species and *Euphorbia antiquorum* is more a succulent than an evergreen.
MEHER-HOMJI (1974) does not emphatically say that *Commiphora berryi* and *Euphorbia antiquorum* characterise a degraded stage of the Dry Evergreen Forest. However, he indicates the degraded character through the occurrence of these species by the close relation he postulates for this type and the Thorn Forest of Southern India, which can be a result of degradation. Both species can occur in both forest types. It can be thus concluded that the Kadavakurichi RF could be a degraded Dry Evergreen Forest.

What can be deduced from the plant sociological classification and the dimensions of the big trees is that the depressed growth of today is not the potential of the Kadavakurichi RF. This knowledge could be use for silvicultural purposes.

[2] according to BRAUN-BLANQUET (1932 in MEHER-HOMJI 1974)

6.2.3 Determination of the vegetation

One aim of the present study was to assess the impact of different intensities of forest use on the structure of the forest. As a first step, the influence of the site on the vegetation structure was tested in order to differentiate it from human impact.

6.2.3.1 Dependency of the vegetation structure on site factors

A correlation between the vegetation and the site factors can hardly be verified through the chosen regression models. The logistic regression was indicated by the small improvement of the -2-Log-Likelihood-value when site factors where introduced as independence. For the given correlations a purely biological explanation could not be found and the power of explanation was not strong enough to be reliable. The model was also not able to estimate the presence or absence of the tested parameters.
The reason for the unsatisfactory results of the logistic regression can be based on the inadequacy of the model or in missing parameters. The first can be excluded because of the fulfilled requirement of independent y-values for a logistic regression. Therefore the reason must lie in the absence of important variables which is most probably the human impact.

The results of the linear regression showed that the explanation of the vegetation through the site factors was low. Where a significant determination was given, the same indirect relationship as already observed in the results of the logistic regression appeared.
The logistic regression has shown that the probability of the presence of trees reduces at higher elevations. Trees are affected by very frequent fires in a way that they are reduced in numbers and are hindered from returning. But if they occurred on higher elevations and in areas with a lower fire frequency or where fire was absent, they generally had more wood than in lower areas but the model did not give a relationship between elevation and crown volume of trees. That means a significant difference between the size of the crown of trees in the lower part of the hillock to those in the upper part, does not exist. In fact, the average length of the trunk at the bottom of the hillock was almost three times smaller than at the top. Trees at a lower elevation are easier to reach and thus preferably cut to those at the top. Also the results for the shrub volume indicate a more intensive use in flat areas and therefore in lower elevations.
The clearest direct explanation of the vegetation through the site factors is given by the model for the biomass cover. It was lower on poor soils and showed high volumes on the better ones. But this correlation is also based on human impact. It can be expected that the vegetation could develop a 100 % cover on all sites, including rock[3]. After a removal of the vegetation it can establish itself again faster on loamy soils than on rocky ground. Primarily this is valid for grasses.

[3] The plot with the highest wood and crown volume index for trees outside the Temple Forest (2,2 m³ wood volume and 589 m³ crown volume) is placed on 100% rock (WS IV, southern exposition).

The first hypothesis was formulated:

H_1: There is no significant correlation between the site factors and the vegetation features.

Based on the results of the logistical and linear regression the hypothesis is not falsifiable. The influence of the site factors that can be shown, is in all cases an indirect implication of human activity.

6.2.3.2 Dependency of the vegetation structure on human impact

The results of the socio-economic survey show clearly, that the usage of the forest was different in the watersheds. This was true for almost all products and for the fire frequency. By including the Temple Forest and the watersheds in the regression models it was tested whether these differing human impacts result in different vegetation structures.
The results for the Temple Forest indicate that a low influence leads to a high cover of biomass and a high wood and crown volume of trees. For these three parameters, the watersheds did not differ much. They could be seen as one unit, which mirrors different influences only to a limited extent. The small explanatory power of the tested vegetation parameter showed that the differences are not big. It can be expected that the fuelwood collection as the main influence determines these differences.
The linear regression also estimated a lower wood and crown volume for WS I and III, which are used heavily for fuelwood collection, than for the other watersheds. But for WS V, the third most used watershed for fuelwood collection, the model estimated higher values than in WS I and III.
In general it is also true that the species harvested mostly did not differ in structure from the rest of the vegetation. Reasons are most likely that these species are generally the most common ones.
Searching for the main reason for these results it has to be stated that the fire had an omnipresent and non-selective reducing influence on the biomass superimposing to some extent the different grades of other uses. Several observations support this assumption. Also, shrubs succeed after fire (AHLGREN & AHLGREN 1960) and therefore cause a relatively high ratio of this phenotype. WS I, the watershed mostly affected by fire, showed the highest probability in the occurrence of shrubs, the highest ratio of plots with a shrub cover above 80 % and clearly the greatest number of shrubs per ha. In addition, this watershed was the one with the highest probability of grasses occurring and the one with the lowest average tree crown volume.
The fire frequency also influences the grass volume. In areas where fire creates space for grass to grow only happens with a low frequency, the grass layer can build up more biomass than under a high fire frequency. Thus the model estimated the highest values for WS V and the lowest for WS II, where shortly before data collection a fire occurred. WS IV, where no fires could be observed, showed relatively high values for the probability of a grass layer and for its volume. According to the fire signs, fires also occurred here, but only to a limited extent. This has to be examined more thoroughly. It indicates that the forest can be influenced by fire even if the vegetation does not show this at the first glance. Under the arid climatic conditions, the present vegetation shows such a slow development

that even a relatively low fire frequency together with wood cutting keeps it in a depressed condition and long time observation is needed to deduce the actual impact.
Impacts other than fire and fuelwood collection can be ruled out as having any visible influence on the vegetation. Regarding the subshrubs it is doubtful whether the high average volume index of the utilised species in WS III was caused by the use here. The differences to the other watersheds were too small.

Not only the vegetation structure was difficult to assign to certain use intensities, also the correlation between the signs of damage and the different uses did not match perfectly. For all three categories of damage signs (browsed, burned and cut) the distribution over the elevations fits these observations. But it must be stated that from the ratio of damaged individuals, the input on the vegetation cannot be directly deduced. The most obvious finding in this sense was the total lack of grazing signs on trees in WS I, where grazing was definitely happening. This cannot be explained. The grade of the damage through grazing of trees and the ratio of browsed shrubs did also not fit the observed intensity. The heaviest grazing through animals belonging to the villagers took place in WS IV while WS III had the highest ratio of heavily grazed trees. The cause here was most likely the influence of foreign shepherds.
The omnipresence of fire damages shows that the entire forest was influenced by fire. The ratio gives a different picture of the fire intensity than what could be observed during the time of data collection. WS V shows a relatively high ratio and WS I a relatively low one. The explanation lies in the tree density and tree size. That a fire affects a tree in WS V was more likely than in WS I where fires were set on the huge grassland and on shrubby areas.
The grade of tree damage through cutting correlates slightly with the intensity of fuelwood collection. Where the use was intensive, especially through professional woodcutters, the ratio of trees showing heavy and medium injuries was higher. It has to be considered that the observed fuelwood utilisation covers only the villages in the study area. The distribution of the cutting signs permits the assumption of an additional influence. This matches the observation of active professional wood contractors made by the PHCC.
If the signs of damage were the only information available to determine the species requirements a different picture than that gleaned through the interviews would appear. Thus it is essential for studies obtaining information about the intensity of human impact and utilised species not to build on such data alone. This is valid also for the signs of trampling and cattle dung. They are not consistent enough to mirror the actual impact.

The second hypothesis set up was:

H_2: There is no correlation between the intensity of the forest use by the local forest users and the vegetation features.

This can not be repudiated completely. Some features of the vegetation can be explained by the observed influences, if only to a small explanatory power, while others cannot. Different influences on the watersheds exist but slow growing vegetation and the omnipresence of fire does not allow their determination clearly.

6.2.3.3 Dynamic of vegetation development

The chosen set up for the data collected did not allow the detection of the development of the vegetation under the different uses and their intensities. But the data gave a frame that permits an estimation of what would happen if the vegetation would face the different forms of human impact under different grades of intensities.

Annual fires lead to the formation of grasslands. If fires would stop and no other human impacts were to happen, an immediate growth of the shrubs would set it. As the example from WS I shows, they are numerous and small with a relatively high fire frequency. Their shoots get burned back annually but their rootstock is relatively big compared to the part that is visible above the soil surface. At which stage of development this vegetation is kept, depends on the fire frequency. If the fire frequency were such that trees could establish, a steppic vegetation with a more or less developed shrub layer under a depressed stand of fire resistant tree species forest dominated by fire resistant species would develop. It can be presumed that even a low frequency of small fires would be enough to keep the vegetation at this stage. Other tree species would most probably only occur if fire is occasional or totally non existent.

Under the exclusion of all influences except fuelwood cutting, the trees would be most used and thus shrubs can be expected to be dominant. If the need for fuel is not too high it is likely, that the shrub layer is not totally removed. Especially the species with the lowest fuelwood value would increase and constantly close the area. The forest would be more and more inaccessible and some parts would possibly even be avoided for collection. If the collection were not too intensive, trees could establish here and form together with the shrubs a dense thicket. These places would be more attractive the bigger the trees become and in a parallel development the shrubs would be reduced under the shadow of the trees. If fuelwood collection is carried out here, it would keep the vegetation in a mixture of thorny trees and shrubs which would be in general denser.

In the plain areas around the Kadavakurichi hillock, where the big herds of the transhuman herdsmen graze, intensively woody vegetation can be observed only in occasional spots. Thus the forest in the study area could also have this open structure if an intensive grazing were the only activity. But the grazing there is less intensive and the hillock not as easy to access as the neighbouring plain areas. It is more likely that under the existing grazing pressure and the exclusion of fire and fuelwood collection shrubs would develop to a thorny vegetation which varies from depressed single plants under intensive pressure to a dense scrub where the pressure is less. Within this thorny thicket unarmed trees could regenerate and a less thorny and higher forest could establish. Once cattle would enter here, the regeneration would be limited to thorny species. The development of the established trees depends on their applicability as fodder. If it is high, the herdsmen would lop the trees and the thorny shrubs would most probably increase according to the tree cover. If the vegetation develops in this way, the forest under grazing as the only impact would vary between dense scrub and open stands with a more or less dense thorny undergrowth.

According to these assumptions the forest cannot develop from its thorny habit if fire occurs. Even with a minimal fire frequency only fire resistant species can survive. Low pressure of fuelwood collection and grazing would permit a further development at least in some places. But in any case thorny shrubs and small trees would dominate the first suggested stage starting from the actual situation and it can be easily imagined that fire is used in order to create accessibility.

6.3 Socio-economic situation

With almost 90% of the households engaged directly or indirectly in agriculture (PHCC 1991) the study area mirrors the situation in rural areas of Tamil Nadu. With 15% of the total population engaged in utilising forest products, the dependency on the forest was not as intensive as in other parts of the country, for example as reported for East India (AGRAWAL & SAIGAL 1996, POFFENBERGER et al. 1996a, JENA et al. 2002 and others) and parts of the Western Ghats such as the Palni Hills (VENKATARAMAN 2000). But for the studied households the forest was an important source of their daily-required products.

6.3.1 Determination of the forest users through their socio-economic status

The watersheds showed differences in their socio-economic and natural settings. How far this influenced the forest uses can't be said clearly. WS IV and V show similar land use patterns but different forest use patterns. People in WS IV were using the RF less for fuelwood. This could be connected to the Vagai River in the neighbourhood of WS IV which is a source of fuelwood and a grazing ground. WS I had the highest ratio of agricultural land and the smallest ratio of land under irrigation. In this watershed most of the fuelwood sellers were found. Further fuelwood sellers however were however also found in watersheds with high portions of land under more intensive agriculture.

The comparison between the households that use the forest and those who do not showed a clearer pattern in some instances. The household size, the house type and the age of the persons involved in the forest utilisation have only a limited determining power. The results here only give the tendency of smaller households and cheaper housing types for forest users. Clear patterns can be seen in the type of the livestock kept, the caste affiliation, the profession, employment and gender ratio among the persons using the forest.

The users kept mainly goats and sheep whereas the non-users showed a higher ratio of households keeping cows and the herd size of sheep and goats of the users was also bigger than that of the non-users. During the interviews and through observation it became clear that the non-users who have herds of more than 7 goats/sheep grazed in the taluk forest instead of the RF.

The cast system in India is of great importance and affects almost all spheres of life. In any study dealing with social matters the cast defines the place an individual or a group of individuals hold in society (see BEALS 1974, WEBER 1997, DILLEN 2000 and others)[4]. Thus it seems obvious that this also effects the forest use even if studies on this relationship are rare. It is well known that tribal communities have a close relationship with the forest. (POFFENBERGER et al. 1996a, SEELAND & SCHMITHÜSEN 2000, JENA et al. 2002 and others). But information about casts specialised on forest use is rare. OSTWALD (2000) found in her study in Orissa, that the ratio of used products are different among cast-groups in the sense that schedule casts[5] have a higher ratio involved in fuelwood collection than others. But she does not differentiate the individual casts. The failures in the attempts to involve the local people in forest management were because of plans not meeting their need and traditional utilisation patterns not beeing understood or considered (SARIN 1995/2001,

[4] For cast and cast system see SRINIVAS (1968), SENART (1974), GALANTER (1984) and others

[5] Casts ranking on the lowest level in the social order (see SINGH 1993 and others)

POFFENBERGER et al. 1996a, Kumar 2000 and others). The knowledge of the affiliation of the different casts with the forest may help to solve this problem. For example in a situation such as at the Kadavakurichi, a forest management without special reference to the Moopar cast cannot be successful.
It is an often stated that a large portion of the forest utilisation is held by women (KUMAR & HOTCHKISS 1988, CECELSKI 1987, both in OSTWALD 2000). In contrast, the gender ratio among the users of the present study showed a higher ratio of men in the main uses. Women were more involved in the utilisation of green manure and medicinal plants. SEEBAUER (1986) found mainly women engaged in fuelwood collection in a project in Himachal Pradesh. OSTWALD (2000) found a high involvement of men in fuelwood collection in one study in Orissa and in another study a higher ratio of women doing this work while men where mainly in charge of gaining other products. SARIN (1995) sees the involvement of women in both fields. Regarding this background it can be stated that the gender distribution in forest utilisation does not only depend on the utilised product but maybe even more on the locally established patterns. A standardised approach for the gender involved in forest management as it is announced in the guidelines for the JFM program of the Indian Government[6] does thus not guarantee success. It seems better to attach this to the gender ratio, which exists for a given product in a special location. That the subject of improper gender participation is an issue is shown by SARIN (1995/2001) on the basis of her observations that women should be more involved in JFM programs and that the exclusion of women can make the management practice ineffective.

The distribution of occupation and unemployment among users and non-users showed that a lack of income and job opportunities is an attribute of the forest users. Coolies in general do not have a regular income and the actual rate of unemployment is higher among the users. Thus it could be concluded that the creation of employment would be a way to reduce the pressure on the forest. It is doubtful if this is true for the non-professional forest users. Employment to the extent which would cause an improvement in the income of a household so much that the cooking pattern switches from wood to kerosene or other sources seems unrealistic in the near future.

[6] Guideline for strengthening of Joint Forest Management (JFM) Program (Circular No. 22-8/2000-JFM (FPD) in SINGH (2000)

6.3.2 The different forest uses and their importance in forest management

Fuelwood

The results make it very clear that the main product utilised from the Kadavakurichi RF was fuelwood. 9% of the total population and 66% of the people engaged in forest collected fuelwood from the Kadavakurichi. For almost 90% of the people fuelwood had the first priority among the collected products and only half had other sources of collection. This fits with the results of other studies for India and neighbouring countries (OSTWALD 2000, KHATTAK 1992 and GIESCH 2000) and mirrors the importance of India's forest as a source of fuel.

But the Kadavakurichi did not only deliver the needed fuel for the households but was also a source of income for almost a third of the fuelwood collectors. In WS I and III, where these households mainly occurred, two things could be observed: the most intensive fuelwood collection and the extension of the collection to other watersheds. It can be stated that the professional fuelwood collectors have a higher demand and harm the forest more than other users and should thus be the first group addressed in activities aiming at change. The fuelwood business creates only a low income (around 50 Rs per day) involving heavy physical work and some of the sellers depend on this income alone. In the frame of a program trying to reduce the pressure on the forest by working on the socio-economic factors, the substitution of the income from fuelwood collection should be a main subject. If alternative sources of income could be provided for these persons, the pressure on the forest could be reduced. The effect may not be very big and not immediately noticeable, but would cut one of the peaks.

Grazing

Grazing cattle in the forest was not a major occupation of the people. Only 2% of all households and 15% of the people involved in forest utilisation grazed cattle in the forest. The number of cattle kept was small with slightly more than 2 per household on average compared with the all India average for rural areas of 4-6 (MISRI 1999) and reports from other areas like 7-10 in Harayan (KAUL et al. 1995) and almost 9 in Pakistan (KHATTAK 1992). But grazing ranked in second place among the forest uses and for the people involved it was the most important activity in the forest. In general, they have herds bigger than 10 individuals. Half of them went to the hillock daily and 40% did not have any other source of fodder than the forest. But even among this small group of people, almost 50% felt the shortage in fodder and some even in the productive wintertime. This indicates that the demand was higher than the amount of fodder that was provided by the hillock. This is valid mainly for WS I. The number of goats feeding on trees and shrubs here was similar to those in WS IV and V but a higher ratio of herdsmen in WS I felt a shortage in fodder for there animals. The lack of fodder could be caused through the intensive fires or the intensive wood collection in this watershed. Thus it can be said, that the actual treatment of WS I does not serve the herdsmen.

POFFENBERGER & SINGH (1996) suggest that the grazing of forestland can be conducted without excessive disturbance if restrictions in space and time are implemented effectively. The limited number of people using the forest for grazing should make this possible.

An additional factor is the transhuman grazing. Moving around with cattle in search of grazing ground has long been a tradition of the practising families and they often use the same routes and seasons for generations (MISRI 1999). This makes them a persistent factor in the study area. They can constitute an unbearable pressure on the hillock with their big herds and should thus be excluded from the forest, as it is already practised.

Other products

Products other than fuelwood and grazing did not play a dominant role in the utilisation of the Kadavakurichi forest. This is surprising against the background of the reported importance of NTFP (KRISNAMURTY 1993, SARIN 1995, POFFENBERGER et al. 1996a and others). The reason may lie in the stage of degradation the forest has or simply the reduction of the demand. Green manure, for instance, did not have the importance that it had previously and thatching material was not required as much as in such times when roof tiles and concrete were limited. An improvement of the product yield may therefore not have a great effect on the situation of forest use in the study area, but should still be considered in connection with new management concepts. For many collectors of these products, the forest was the only source and a considerable amount of biomass was removed. The development of the used plants due to an improvement of the tree cover in the forest remains a speculation because of the lack of dynamic data for the vegetation. But it can be deduced that the main plant type (subshrubs) used, would be reduced in their appearance with an increasing tree crown cover as shown in the Temple Forest. On the other hand, the example of WS I showed that a high fire frequency reduces subshrubs.

One important source of income for a considerable amount of people in WS III and I was honey. It is doubtful that the yield can be improved through a change in the forest vegetation. A more promising way to establish a honey production outside the forest would be with artificial beehives. The PHCC has several projects running in this field and one must query why there is so little establishment in the study area.

6.3.3 The scope of action

In the context of the degradation of forests through an over use the question for alternatives has to be raised. That the creation of alternative sources for forest products, mainly fuelwood can have a positive impact on the people as well as on the forest is shown by OSTWALD (2000). But all action in this direction failed in the study area. The plantations on public land owned by the PHCC do not exist any more. On private land trees which are suitable for fuelwood are not preferred. KRISHNANKUTTY (1992) found in a study in Kerala, that such species took only 2% of the total number of planted trees and only 0.16% of the total tree volume. On dry land people prefer dry crops instead of trees and trees are planted mainly if irrigation is necessary. But these trees do not substitute forest products. Tree species suitable for this are only planted if encouraged and supported by institutions but maintenance of these plantations can hardly be observed. Even if a sustaining tree planting program on private land in the study area could be conducted successfully, it is still connected to the availability of private land and the ratio of benefiting households would be the highest in the watersheds with the best forest, WS IV and V.

The only actually existing alternative to fuelwood mostly mentioned by the villagers was residuals on agricultural fields, a source that can hardly be improved because it can be presumed that the material available here is completely consumed. The same is true for coconut fields.

In search of improvement it seems most promising to concentrate on places where fuelwood has already been collected. Such a place was the tank in WS III, which was an important source in this watershed. Protection and controlled use here could provide more fuelwood. Other public lands are another possibility, but here control must be guaranteed.

The creation of alternatives to the products collected in the forest would be of great help in the establishment of better forest vegetation. But the possibilities are limited. Any action in this direction needs a clear definition of the gained product, the beneficiaries and a long term management.

6.4 Fire

It can clearly be seen that fire was the main influence and from this arise questions about its causes and its management. Answering the first question turns out to be quite difficult. There is neither information about the motivations for setting fire in the available literature, nor did the results of the questionnaire and the observations in the field lead to an answer beyond estimations. One argument against the assumption that the fire is used to keep the vegetation in a productive form (RENSBURG in GOLDAMMER 1993 and KURIAN & SINGH 1996) is that most users saw the vegetation harmed by the fire and only a fractional part thought it to be beneficial. This is not an exception. In the study of KURIAN & SINGH (1996) not one of the questioned people thought positively of the fire.

In order to direct the fire it is essential to detect the people causing it and to know their motivations for burning the forest. Because regenerating thorny shrubs and trees make it difficult to move on the hillock, this could make it likely that the keeping open of the access is a major reason but this does not seem to be the only one.
The fuelwood collectors have an interest in harvesting wood. The fire serves their interests only as long as woody vegetation is present and can be treated as a coppice forest, using fire as a tool to kill the upper part of the woody plants. Fuelwood utilisation can thus be excluded as a reason for burning the grasslands. In the watersheds with high demand and regular fires (I and III), the shortage of fuelwood was felt by more people than in WS V with a comparable demand but less intensive fire influence. Thus it can be stated, that WS I and III are beyond the point of benefit for the fuelwood collectors with regard to the fire intensity.
Herdsmen can be excluded due to the lack of grazing signs, the grazing cattle type and their distribution on the hillock. Goats, the main type of grazing animals, do not feed on grasses. The animals feeding on the grasses do not graze on the grassland at the top of the hillock. The herdsmen of goats should have an interest in the presence of trees and shrubs. This means that fire would be a loss for them. The utilisation of grass can also be excluded, because the demand within the study area was low and cutting signs on grasses was not observed. It can also be presumed that the fire is not lit to support the other products. A connection between the fire and green manure or medicinal plants was not visible. It does not seem likely that honey collectors burn the forest willingly, because the grasslands are of no benefit to them.
What remains, as reasons for the fires are religious and cultural motives, charcoal collection, playing children and smokers. Even if GOLDAMMER (1993) and many of the people interviewed named the last two as possible reasons, it is doubtful that mostly random events of fires create such strait fire lines wherever the fires occur. Charcoal collectors need the fires in order to harvest their product and could thus be involved in burning areas with trees but this does not explain the fires on the grassland. The burning of these areas is most likely not motivated by a direct profit but instead through the believe to cause rain due to the creation of clouds.

Nevertheless the strong influence on the vegetation that fire has makes a clarification of its causes necessary if any change in the forest management is to be achieved.
Regarding fire management it can be assumed that this traditional old land use system cannot be stopped in a large area using methods of banning and punishment. In addition, very little is known about the dynamics of these forests under the exclusion of fire. It seems obvious that it leads to an increasing of biomass and also to an improvement of the forest value has also been reported (MALHOTRA & POFFENBERGER 1989 and POFFENBERGER et al. 1996a). But that this improvement is not always the one aimed for, was experienced by Brandis. After several successful exclusions of fire, less valuable trees sprouted in teak (*Tectona grandis*) and Sal (*Shorea robusta*) forest (GOLDAMMER1993). And SARIN (1995) reports from fire protected Sal trees reaching a height that made it impossible to collect the leaves, making the manufacture of important income generating leaf plates impossible.
The involvement of fire as a tool in locally orientated management plans with adapted targets seems a more feasible alternative than a general ban. Fire was generally known as a tool in activities regarding nature conservation but not for forest management (ROGERS 1986, CHRISTENSEN & MAISEY 1987). Already ten years before a "vital need for a whole range of fire management systems" (STOTT et al. 1990 p. 41) and the integration of fire as a prescribed burning in the forest management (GOLDAMMER 1988) was postulated. Since then some African countries and Indonesia have started trials to involve fire in the forest management (GOLDAMMER 1993).

6.5 Policy implications necessary

A prior condition in India would be the legalisation of fire to an extent of allowing its involvement in local forest management on the basis of a targeted research on the patterns of the fires.
Regarding the JFM program it is often criticised that the local people are not involved in planning and benefiting as much as would be needed to raise their interest and increase their participation in the program (AGARWAL & SAIGAL 1996, POFFENBERGER & SINGH 1996, KUMAR 2000, CONROY 2001 and others). A similar situation can be seen in the study area. The selection of the villages involved does not represent the extent to which they are utilising the forest. Out of WS I, where a great part of the forest users live, not one village is involved. Further programs require a more precise application here.
According to the information from Mr. VENKADESH, DFO Dindigul (Interview on 20.02.01) and Mr. VIJAYAKUMAR, forester Batlagundu (Interview on 14.12.00) the selection of the planted tree species in the JFM program was aimed at the production of NTFP. But the product that is mostly required is fuelwood and thus this should be produced first. The forest users in the Kadavakurichi area have no right to cut living trees, but to collect dead wood. Dead wood is present in a totally insufficient amount. As is assumed above, it is the "production" of dead wood that leads to the fires at least partially and this means the creation of the depressed vegetation and the waste of wood. If the aim of the FD is to increase the biomass on the hillock and to serve the requirements of the local people with this forest management, then the authorities have to think about the abrogation of the tree felling.
To transfer the ownership of the forest to the local users, which is possible on the basis of article 33 of the Tamil Nadu Forest Act (SINGH 2000), it should perhaps be discussed in

areas where a traditional forest management exists like the one described by POFFENBERGER et al. (1996a). Here traditional forest uses exist among a relatively homogeneous population that can not be compared with the multi sociological population around the Kadavakurichi hillock.

Only a very small number of people had ideas of how to change the usage pattern. Any activities to improve the source of forest products, within or outside the RF, need the guidance of well-trained staff (see also GOLDAMMER 1993, PALIT 1996 and MCGEAN et al. 1996). The FD has the required infrastructure and could play a key role here. But irrespective of the fact that the FD is a long way from transferring forest ownership in the course of the JFM program, it is be doubtful whether the dedication of the foresters would be higher in such a situation than it is at present. It is more realistic to improve the existing administrative settings through training the FD for a fruitful support of a Joint Forest Management.

6.6 Prognosis for the development of the Kadavakurichi RF

As shown in chapter 2.2.2 the official data about the growth and utilisation of India's forests does not indicate a sustainable utilisation regarding the definition given in chapter 1.1. The same is valid for the actual forest use of the Kadavakurichi, because "biodiversity, productivity, regeneration capacity, vitality and their potential" are not maintained. But sustainability can also be taken as a method of use that constantly provides the gained product. BERKES & FOLKE (1998) state: "… that social-ecological systems which have survived over extended periods of time are sustainable" (p. 20). Now we have to ask if the production of the Kadavakurichi satisfies the actual and future needs under the present utilisation pattern.

The most important product was fuelwood. The amount used, calculated for the total population, varied between 120 kg ha^{-1} in WS IV and almost a 1000 kg ha^{-1} in WS I. Over the total RF, 0.47 m^3 were removed per ha and year. Growth data for a vegetation type found on the Kadavakurichi RF does not exist. In the following calculation the annual growth rate of 0.41 m^3 ha^{-1} a^{-1} given by SINGH (1992) and LAL (1992) for dry forests of the Indus plains shall be used.
The growing stock per ha was based on the used wood volume index of 36 m^3. This is less than half of the average for the whole of India given by SING (1992). The growing stock for the different watersheds is given in the next table:

WS	Growing stock m^3/ha^{-1}
I	20
II	26
III	26
IV	40
V	50
Entire RF	36

Tab. 6.1: Growing stock in the KV RF

The calculation for the development of the growing stock of the Kadavakurichi shown in figure 6.1 (next page) assumes a constant increase of the volume regardless of the actual growing stock. The extracted amount of fuelwood was calculated for the people settled in the study area and was based on their information. It does not include wood extracted from people outside the study area and the wood that is lost through fire. Thus the following figure may draw an optimistic picture, but it also gives a good impression of the different development trends of the watersheds.

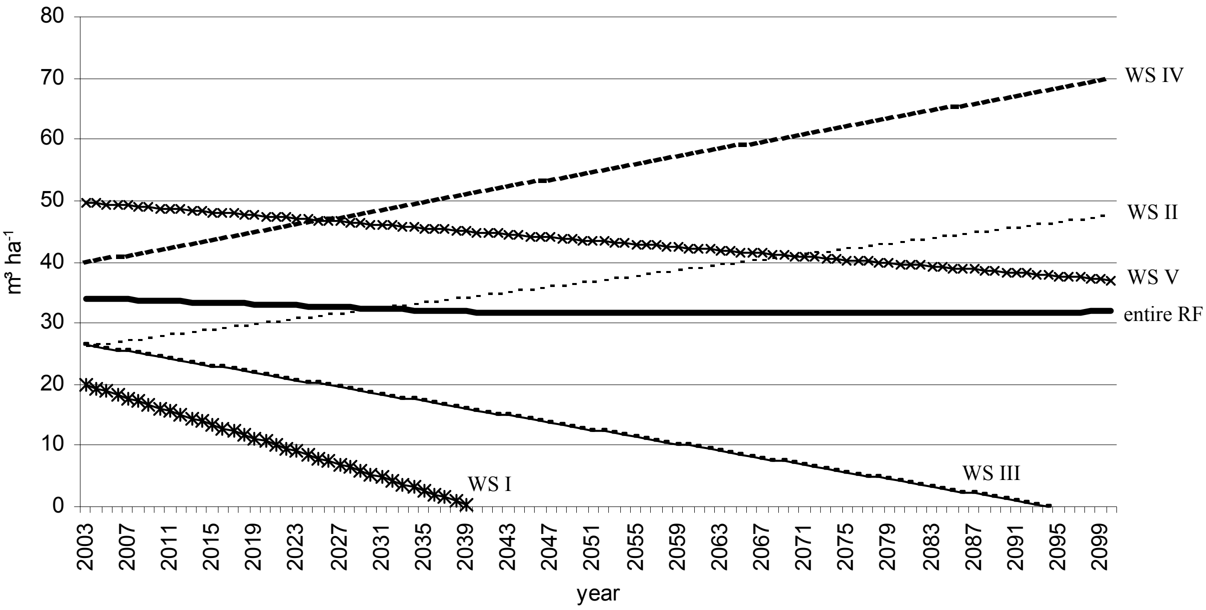

Fig. 6.1: Development of growing stock for the watersheds

This scenario is much less dramatic than that based on data for the whole of India (see chapter 2.2.2). It shows that the Kadavakurichi RF is somehow stable in its growing stock. If the heavy use of fuelwood in WS I would persist, this watershed will loose its growing stock in the next 40 years. The growing stock in WS III would also be reduced constantly while in WS V the growing stock declines much slower. The moderate fuelwood collection in WS IV and II allows this growing stock to almost double its amount during the next hundred years.

In the figure, the growing stock of the entire RF increases slightly after WS I and III run out of wood. This would not be the case in reality, because the demand for fuelwood would still be there and the wood would most probably be collected in the other watersheds.

But the scenario still shows that the present use of fuelwood from the Kadavakurichi is not so far from sustainability at this low level of existing growing stock. The vegetation of the RF has a good chance of staying or even improving if regulations are implemented which would be able to reduce the pressure on the forest.

6.7 Conclusion and future perspectives

In order to provide a constant supply of forest products, the development of silvicultural systems has to build on information about the dynamics in the growth of the wanted products. Such data are essential for forest management but unfortunately are almost completely lacking for the studied forest and similar forest types. They have to be raised for every product removed from the forest but primarily for the most important one: fuelwood. This requires studies on the growth rate of the present forest and on the growth rate of suitable species for the respective sites. The latter should not be very difficult to estimate, if the age of the stands consisting of these species is known. The problem is that such stands are rare, in general very young and not persistent. In addition they may exist on better sites and not on those representing the studied forest. However, comparable stands may exist in some places and data about their volume should be raised.

Regarding the growth rate for the existing forests it is necessary to know more about the amount of fuel that can be harvested under different utilisation intensities and with additional human impact such as fire and grazing. This requires the evaluation of the development under different utilisation scenarios. The data could be raised in two ways: The construction of permanent sampling plots or the selection of forests in different stages of development. As mentioned above both ways need long term observation. For the first case the different uses have to be applied experimentally and it is doubtful whether this can be put in practice. What could possibly be done is to protect a few controllable plots. In a short period of time this would give an impression about the development of the vegetation in the first stages of succession.

The selection of forest under different influences seems to be a more promising way, if one gives up the idea of raising exact information about the influences and builds on what can be evaluated such as has been done in this study. If different forest vegetation is described on comparable sites and the influences can be at least partially controlled, unreal time series could be conducted to give a rough picture about the development of the forest.

Considering the long term forest management where fuelwood is not the main product wanted and in order to know more about the species composition and structure of the climax forest, one needs to search for a forest showing a further stage of development. Even if they are rare, it can be expected that these areas exist as small hidden temple forests like the one in the study area or as patches somewhere in the landscape difficult to access. It would take some effort to find them and there may be a vast difference in site conditions. Therefore it will be hard to evaluate the effect of human impact independent of the site but it would at least give a rough picture about the direction the succession is likely to take.

For determining the vegetation development under human impact, fire plays a central role. In chapter 6.1.3 ways were described to show the interaction of fire and vegetation. If it is possible to determine which vegetation type results from a given fire frequency and intensity, one could estimate the amount of fuelwood or other products to be produced. Then fire could be used to regulate the supply of the products required. But this is not possible without the knowledge about the causes and motivations for setting the fire. The present study has only reached a limited level and has shown the difficulties in ascertaining these motivations. Simultaneously it can be seen that fire and its sociological background should be a central field in future studies about forest use in the dry parts of India. This

would mean a creation of trust among the people in the study area, thus requiring sensitive research.
Results arising from this will reveal the importance of fire in the forest management. Legislation dealing with the welfare of the rural population as its central concern would find substantial reasons to create a legal frame for the involvement of fire in the forest management.

The introduction of Joint Forest Management as a major tool in the utilisation of India's forest provides the basis for the implementation of management systems. In practice, the joint management often does not work successfully especially in long term forest management concepts. As a first step it seems helpful to find examples JFM or similar forest management systems carried out successfully. The causes for their success have to be analysed and the possibility of transferring these systems to other areas have to be proved. Where the transfer of such management systems is not possible, due to different forest ownership, user rights etc. the research would have to concentrate on development and implementation of new methods.

7 Proposals for further management

The Kadavakurichi RF is a degraded stage of a forest rich in biomass. The methods of forest use that lead to this stage have been in use for the last 200 years at least. If an applied forest management aimed at big trees, the methods of use would have to be completely changed or even excluded. This is unrealistic. The aim should be to improve the supply of the products actually wanted with the methods of forest management currently in use, rather than installing a totally different forest management system. Thus the aim of the actual management has to be the production of fuelwood and fodder. Space should be provided for fires based on religious and cultural motives as well.
Silvicultural possibilities that could be conducted under less pressure and taking the site potential into consideration are outlined at the end of this chapter.

7.1 Management with focus on the products actually demanded

An increase in the growing stock while continuously using the wood can only be achieved under a management, which is based on product collection in allocated zones. This is not a new idea. TROUP (1907) already recommended a management plan for grazing by zones 100 years ago.
The uncontrolled burning leads to a high loss of wood and keeps the vegetation on a low level of biomass development. As mentioned above, a banning of fire would not lead to any success and thus GOLDAMMER (1993) calls for the implementation of fire in the utilisation of tropical forests. He stated that the desired product of the forest management must be clearly defined and that fire can then be used as a tool for recommended burning to the extent needed. All fires that do not support the set aim have to be excluded.

7.1.1 Regulation of fire in zones

For a fire regulation, a legal basis, the knowledge of the persons lighting the fires and their motivations are required. This will lead to different fire zones with alternating fire frequencies. Between the zones, fire brakes will have to be installed to prevent the fire from spreading from one zone to another. These fire brakes have to be created by the removal of the biomass up to the mineral soil (see figure 7.1). If fire watchers are present during the burning to control the flying sparks, a width of 3 meters for the fire breaks should be enough.

7.1.1.1 Fuelwood production

The exclusion of fire would lead to an increase of the present vegetation. This means that the areas with an open structure would turn into an impassable thorny thicket and therefore a fuelwood collection would be very difficult. Thus the intended vegetation type is a loose stand of trees as it is established in WS IV. The trees may show a dense crown cover consisting of *Commiphora berryi* and planted fuelwood species.
The lack of growth data makes it difficult to give exact rotation times, number of zones and the amount of wood which could be extracted in a sustainable system. Thus the rotation of different treatments is not given in a time scale but as three phases:

Phase 1: Total protection

Phase 2: Open for uses others than fuelwood and grazing

Phase 3: Grazing, burning and fuelwood collection

In the first phase the forest can regenerate to produce biomass. This will consist of grasses, subshrubs and shrub coppices in the burned areas. In the second phase the collection of NTFP could be carried out and in the beginning of the third phase when trees are no longer harmed by grazing, grazing of goats can be allowed. At the end of this phase shrubs have to be burned back and then removed by hand. The accruing wood can already be used as fuel. Dead branches of the trees could be used as fuelwood as well. For the selection of the harvested trees it seems suitable to fix a certain diameter. The third phase ends when all these trees have been harvested. Each zone should be able to provide the needed amount in the time set for collection.

The zones for fuelwood collection should be located above 300-400 meters in all watersheds. In watershed I and II up to the borders of the grasslands which are reserved for religious and cultural motivated fires (see below). As shown in chapter 5.2.2.1 the fuelwood collection was not only limited to the watersheds inhabited by the collectors. Thus the zoning does not have to be done for every watershed separately. If WS I and V were taken as one unit and WS V was divided in two zones, fuelwood collection could be conducted during the first two phases in WS V in the first and second zone respectively while WS I could regenerate. This would result in a longer travelling distances for the fuelwood collectors from WS I but poor development of trees in WS I makes a protection here necessary. WS II and III could also be taken as one unit and the few fuelwood collectors from WS II could collect in WS III to enable the vegetation in WS II to recover. WS III should be divided into three zones. One at the top, reserved for afforestation, and two more in the northern and southern part of the watershed. In WS IV two zones above 300 meters should be established to compensate the demand created in WS III.

If the demand for fuelwood becomes less or if the proposed system supplies an amount above the actual demand, the tree cover could be developed to a density that reduces the thorny undergrowth. This would allow accessing the area without the use of fire and therefore the growth of non-fire resistant but fast growing tree species could be encouraged.

Afforestation

Further tree planting for additional fuelwood production should be tried. If the fire is kept out of the grasslands at the top of watershed III, a fuelwood plantation could be established here. This area is less steep than the other sites of the hillock and should provide better growth. It already contains a piece of dense scrub, which is slightly better developed than in other parts and should be totally excluded from the fire. On the remaining area the first phase has to be conducted until the trees are well established. The fire should be used in such a way so that the planted species survive and the remaining vegetation does not develop far beyond a pure grass layer. The tree species used need to be drought and fire resistant as well as fast growing. Fire resistant tree species are *Hardiwickia binata*, *Pterocarpus santalinus* and *Erythrina suberosa*. But they are growing slowly. Species that grow faster but are less fire resistant are *Prosopis juliflora, Albizia lebbeck*, *Acacia*

holosericia, *Cassia siamea* and *Wrightia tinctoria*. These trees have a good chance to regenerate as coppice after a fire.
It is important for any tree planting that the seedlings are planted in the shadow of the existing shrubby plants. This is essential for their establishment because here the conditions are better than in the open sun. Additional planting can be done at the beginning of every cycle in order to eventually close the remaining gaps.

7.1.1.2 Grazing

The grazing activity differs according to the type and number of cattle in the watersheds. Sheep are mainly present in the lower areas of WS III and IV while goats roam around almost all over the hillock.

Sheep

A solution to combine tree growth, grazing and fire was described by GOLDAMMER (1993) in his "silvipastoral systems". These systems allow for grazing of animals under fire resistant trees, while in a cycle of burning and grazing, unwanted vegetation is kept from developing and the grass layer is maintained. The uncontrolled formation of forest in the savannah follows the same principles with the exception that the latter is applied rather uncontrollably. The planned burning of such stands allows the accumulation of biomass in the tree layer and the maintenance of grasses. Again zones have to be established and the proposed phases mentioned earlier should be implemented. The required species should be planted at the beginning of the first phase. Only when the seedling can no longer be affected by fire, then the ground can be burned in order to provide a fresh grass layer. Through the fire frequency the ratio of grasses and shrubs can be determined according to the type of fodder that is required. If shrubs and small tress are permitted, goats could also be fed.
The trees which are fire and drought resistant, beside those existent are *Pterocarpus santalinus* and *Hardwickia binata*. They provide timber and their leaves have a limited fodder value.

Fig. 7.1: Grasses with fire break under *Hardwickia binata* (age unknown)

If the production of fodder is the main aim for maintaining the tree layer, the only suitable species are the existing ones like *Commiphora berryi* and *Acacia planifrons*; for the latter the fire resistant quality of the adult trees has yet to be proved.
Trees that are suitable for fodder like *Ailanthus excelsa*, *Leucaena leucocephala*, *Albizia lebbeck*, *Azadirachta indica* and *Albizia amara* are generally not fire resistant. Some trees could be observed on the hillock, which had survived low fires. If individuals of some of these species could be established in areas with only low fires, a much better production of fodder would be possible.

Silvipastoral systems with planned fires can be established in areas up to 300 m elevation. In general they are possible in all watersheds but the highest demand was in WS III and IV. The area below 300 m in WS IV is quite big (see figure 3.3) and would provide enough space for these systems. In WS III an extension up to 400 meters seems to be appropriate.

Goats

Goats allowed to graze all over the hillock mainly feed on shrubs and trees. Thus a silvicultural system aiming at grasses is not suitable. A modification of some zones in a way that permits shrubby undergrowth would enable the grazing of goats as well.

In upper elevations the goat grazing has to be combined with the fuelwood management. But the cut trees can not coppice again if they are under grazing pressure. Thus the grazing can only be allowed in the last phase before the zone is reburnt again.
If grazing of goats and fuelwood production in the same area is not possible, different zones have to be set up especially for grazing. These zones could be handled easily, because they only have to be grazed and burned, and this phase can be shorter than a year (TROUP 1907). Even so the lack of fuelwood and grazing ground through the partial protection of the forest can lead to a lack of space. In addition the effort of organising and supervising increases.

7.1.1.3 Other products

The analysis of the vegetation data does not reflect the factors determining the growth of subshrubs. It seems that a high fire frequency and a closed tree canopy lead to a reduction of these plants. It can be guessed that subshrubs can develop in the fuelwood zones. The fire frequency is low and the tree canopy is never completely closed. Honey, thatching and fence material should also still be available.
Green manure trees like *Wrightia tinctoria* can improve the green manure production if involved in the silvipastoral systems.
If additional income through NTFP is desired, tree species are needed which can withstand the fire and provide income-generating products. Examples are *Emblica officinalis*. The fruits of this small tree find a great demand on local markets because it is of medicinal value.

7.1.1.4 Regulations for fires set for reasons other than product utilisation

Fires set to cause rain or for other cultural or religious reasons are in danger of destroying all other efforts to increase the productivity. It can be guessed that these habits have a tradition and can not be changed in the required time frame. Thus it seems more efficient to define special areas which can be burned for this purpose. The grasslands which do not contain any woody biomass seem to be a good place. Among them the less productive areas should be chosen, which can be found on the upper slopes of WS I and II. The small groups of *Erythrina suberosa* at the top of WS II should be protected from the fires.

7.2 Management with focus on timber supply

The silvipastoral systems, as recommended for the lower elevations, can produce timber. Small zones under this management type could be established also in other parts of the hillock.

If the situation changes and the pressure become less and/or protection and utilisation of the forest is well established in the frame of JFM programs, then timber production in long-term silvicultural systems can be considered. It is clear that the Kadavakurichi is able to support much better vegetation in the sense of a dense tree cover containing a higher volume of wood than at present. Systems, which try to make use of this potential may be of a more theoretical character and it would be essential to prove this in the field. Proposals for the growth of timber are therefore very speculative. The growing potential of an undisturbed forest includes the development of the soil and therefore an improvement of the site. This is a long-term process and thus the situation must be such that the human interference is much less than at present and an exclusion of fire is guaranteed. A situation of protection such as that of the Temple Forest for example.

The tree species used to produce timber do not have to be fire resistant under the supposed conditions. Thus a wide variety of species is available. The best sites for timber growth is most probably the top of WS III and should be reserved for high value timber trees like *Diospyros ebenum*, *Dalbergia latifolia* and *Santalum album*. On the other sites species such as *Acacia leucocephala, Pterocarpus santalinus*, *P. marsupium*, *Hardwickia binata*, *Holoptelia integrifolia*, *Erythrina suberosa*, *Albizia lebbeck* among others could be planted.
The selection would be made according to the required type and dimension of timber. It can be conjectured that through the improvement of the site, the growth of the valuable species is possible on the entire hillock.

7.3 Management of the Kadavakurichi in the frame of JFM

To conduct the above mentioned forest management systems in the study area the most important points are:

- Continuation of the JFM programme
- Involvement of all villages using the forest, especially Kamatchipuram in WS I
- Protection of the forest from external users
- Identification of the people causing fire and their involvement in the prescribed burning
- Identification of the fuelwood sellers and their involvement in the fuelwood management

The JFM provides an ideal frame to implement the proposed or other forest management systems. It is crucial for success that the forest dwellers are involved more in the forest management than they are at the moment. That this has to include all forest users and not only a fraction of them, is obvious. An extension of the JFM program provides the changes necessary to replace a higher number of goats through milk animals as has been done so far.

An important point is the protection of the forest from external users. Any fire or woodcutting from groups other than those located in the study area makes the establishment of forest management systems useless. Great effort is necessary to make the communities within the study area feel that it is to their own benefit if external influence is excluded in order to motivate them to participate in the forest protection.

An intensive control of the prescribed burning is necessary. Knowledge of fires exists among the people who set the fires. An attempt should be made to involve these people in the fire management as fire experts, to select the burning fields, set the fires and control them. The fire fighting group from Kombaipatty as well as additional groups that had been formed should be involved in the fire control. The installation and maintenance of the fire lines provides job opportunities for local users.

Any benefit that comes from the forest management should only be given to the villagers. The Micro Plan has to fix the harvested amount and the distribution to the households for use and selling.

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Working Plan for the Dindigul Forest Division. Ist April 1984 to 31 March 1994

Appendix

Appendix 3.1: Cast distribution among the total population in the study area in percent watershed wise, PHCC-census 1996

	WS I	WS II	WS III	WS IV	WS V	total
Moopar	32	-	52	-	-	23
Thevar	11	64	1	19	20	17
Nayakkar	12	<1	2	13	48	14
Chettiar	4	17	7	13	1	7
Pillai	-	-	-	30	8	6
Servai	14	-	-	-	6	6
Kattu Nayakkar	16	-	-	-	-	6
Naidu	-	-	21	-	-	5
Sakiliar	3	8	8	4	-	5
Pallar	<1	-	1	18	-	4
Maniar	6	-	4	1	-	3
Asari	-	10	<1	1	9	2
Dobi	1	-	2	1	1	1
Maravar	-	-	-	-	7	1
Barber	1	1	1	<1	1	1
Nadar	<1	-	-	<1	-	<1
Iyyar	-	-	<1	-	-	<1
Konar	-	-	<1	-	-	<1
Ottar	-	-	<1	-	-	<1
Gounder	-	-	<1	-	-	<1

Appendix 3.2: Extract of important forest types for the study area out of the classification from CHAMPION & SETH (1968)

II – Dry Tropical Forests

Group 5 – Tropical Dry Deciduous Forest

Sub-group 5A – Southern tropical dry deciduous forests:

C_1	Dry teak-bearing forest
1*a*	Very dry teak forest
1*b*	Dry teak forest
C_2	Dry red sanders-bearing forest
C3	Southern dry mixed deciduous forest

Degradation stages of tropical dry deciduous forest

DS_1	Dry deciduous scrub
DS_2	Dry savannah forest
DS_3	(Euphorbia scrub)
DS_4	(Dry grassland)

Group 6 – Tropical Thorn Forests

Sub-group 6A – Southern tropical thorn forests:

C_1	Southern thorn forest
C_2	Karnatak umbrella thorn forest
DS_1	Southern thorn scrub
DS_2	Southern *Euphorbia* scrub

General edaphic, degraded and seral types of thorn forest

E_1	(Euphorbia scrub)
E_2	Acacia senegal forest
E_3	Rann saline thorn forest
E_4	Salvadora scrub
DS_1	Cassia auriculata scrub
IS_1	Desert dune scrub

Group 7 – Tropical Dry Evergreen Forest

C_1	Tropical dry evergreen forest
DS_1	Tropical dry evergreen scrub

Appendix 4.1: Check list for the vegetation survey

Date: Expos.: % of living cover: Soil type: Humus: L: Total No. of species:
Area: Slope: % of dead a. living cover: Of:
Watershed: Altitude: % of rock: Soil depth: Oh:
Ah:

							Cover				Height (m)				Diam (cm)			
	Plot-No.	Ind-no	No. of Ind	Type	Botanical Name	Tamil Name	species cover %	% of plot	Ind. %	Foliage	tallest	A	*est**	Base of crown* (m	T 1,3 (th)	A	S 0,0 (th)	A
Line	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		

C= Climber
T= Tree
S= Shrub
H= Herb
WH= Woody Herb

Timing: reached the plot from: in min
data collection:

dead wood % down: diam (0,5) trampled %:

up: diam (0) Dung % cow:
hight: Ind: goat:

			Crown radians (cm)												
	No. of trunks 0	No. of trunks 1,3	N	NW	W	SW	S	SE	E	NE	grazed	burned	cut		
Line	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															

Appendix 4.2: Village wise break down of the number of Interviews

WS	Village	Fuelwood collectors	Cattle grazers	Others	Non-users	total No. Interviews	total No. Households	Map used
I	Veelinayakenpatty	13	6	0	20	39	232	yes
	Papponayakanpatty	2	1	0	11	14	116	yes
	Jeyanayakanpatty	0	0	0	10	10	100	no
	Maniakaranpatty	0	0	0	17	17	171	no
	Kamatchipuram	29	1	1	7	38	126	yes
	Pudupatty	0	0	0	27	27	271	no
	Duraisamypuram	0	0	0	7	7	68	no
	Mutharaiyar Nagar	1	1	0	3	5	31	yes
	Sum	**45**	**9**	**1**	**102**	**157**	**1115**	
II	Kurumbapatty	15	3	0	13	31	167	yes
	Mallanampatty	0	0	0	11	11	111	no
	Sum	**15**	**3**	**0**	**24**	**42**	**278**	
III	Kombaipatty	46**	15**	25	26	112	421	yes
	Kulipatty	0	0	19	17	36	206	yes
	Sum	**46**	**15**	**44**	**43**	**148**	**627**	
IV	Pudur	5	3	0	10	18	116	yes
	Sivagnanapuram	2	0	0	20	22	200	yes
	Bodiagoundanpatty	0	0	0	18	18	182	no
	Sum	**7**	**3**	**0**	**48**	**58**	**498**	
V	Andipatty	12	3	0	7	22	95	yes
	Milakaipatty	15*	4	0	4	23	79	yes
	Muthukammapatty	0	0	0	5	5	51	no
	Musuvanoothu	0	0	0	18	18	182	no
	Sum	**27**	**7**	**0**	**34**	**68**	**407**	
	Sum WS I -V	**140**	**37**	**45**	**251**	**473**	**2925**	

* One interview less because of no sufficient response.

** Two Interviews in one household occur.

Inequalities between the number of interviews and the total number of household are caused by more than one interview in some households and uneven total number of household in one strata and village.

Appendix 4.3: Questionnaire

WS: Village: Houshold-No.: Date:
From: till:

Researcher: Interviewer: Notes:

Observations:

Housetype	bricks	☐	rooftype	tiles	☐
	Clay	☐		coconut fibre	☐
	light material	☐		grass	☐
	stones	☐		concrete	☐
				asbestos	☐
				corrugated iron	☐

I1 What do you think about the KV-forest? Give your opinion please!	
I2 When did you go to the forest the last time?	within the last week ☐ six moth ago ☐ within the last five years ☐ two weeks ago ☐ one year ago ☐ before five years ☐ last month ☐ two years ago ☐ no answer ☐ others:____
I3 For what purpose did you go there?	
I4 Why do you go there? Rank according to the importance!	grazing ☐ collecting Grasses ☐ nothing ☐ hunting Animals ☐ collecting Medical Plants ☐ no answer ☐ collecting Firewood ☐ collecting Green manure ☐ collecting Small Timber ☐ collecting fence material ☐ others ☐

Fuelwood and others products

P1 How often do you go for Product collection?	daily ☐ once a moth ☐ more than once a week ☐ more than once a month ☐ once a week ☐ less than once a month ☐ not at present ☐ once in six month ☐ once a year ☐ no answer ☐
P2 When do you go?	Summer ☐ all year ☐ Winter ☐ no answer ☐
P3 Where? (show photos)	WS Elevation: everywhere ☐ WS Elevation everywhere ☐ WS Elevation everywhere ☐ all WS's Elevation everywhere ☐ no answer ☐
P4 What species do you collect? Which is the most important?	
P5 How much do you collect each time you go?	
P6 Which Part of the plant do you collect?	
P7. Do you face shortages for that product on the hillock, and if so, when?	Summer ☐ all year ☐ Winter ☐ no shortage ☐ no answer ☐
P8 For what purpose do you collect the product?	
P9 Who else from you household goes for product collection?	
P10 Do you have other sources for product collection?	
P11 Do you have any idea how to get more of the product?	
P12. Do you use or collect anything else from the forest?	Go I4

Cattle

C1 How often do you go there with your animals?	daily ☐ once a moth ☐ more than once a week ☐ less than that ☐ once a week ☐ I do not have/or take animals to the hillocks ☐ more than once a month ☐ no answer ☐
C2 When do you go?	Summer ☐ Winter ☐ all year ☐
C3 Where? (show photos)	WS WS WS all WS's Elevation: Elevation Elevation Elevation everywhere ☐ everywhere ☐ everywhere ☐ everywhere ☐ no answer ☐
C4 What animals? Rank their importance according to their number	Goats ☐ Sheep ☐ Kadaimadu ☐ Bullok ☐ Cows ☐
C5 On what do they mostly feed on the hillock? Which is the most important?	
C6 Which part of the plants?	
C7 Do you face fodder shortages for them on the hillock, and if so, when?	Summer ☐ all year ☐ Winter ☐ no shortage ☐ no answer ☐
C8 Who else from you household goes for grazing?	
C9 Do you have other sources for grazing?	
C10 Do you have any idea how to get more fodder?	
C11. Do you use or collect anything from the forest?	go I4

IMPROVEMENT	
IM1 What can be done for an improvement of the forest?	
IM2 What can you do to improve the forest?	
IM3 Very often there is fire on the hillock! Do you know why? Give your opinion please.	

Socio-demographic data

D1 How many people are living in your household?	no answer □
D2 How many ... you have?	Goats Sheep Kadaimadu Bullocks Cows Other None no answer □
D3 What is your profession?	Profession 1 Profession 2
D4 Are you employed?	Profession :1 Yes □ No □ Profession :2 Yes □ No □
D5 Do not ask. Observation !!!	Male □ Female □
D6 What is your age-group?	<14 years □ 19-30 years □ 41-50 years □ >60 14--18 years □ 31-40 years □ 51-60 years □
D7 Which community you belong to?	Don't ask. Observation.
D8 Do you own land?	Yes □ No □
D9 Do you grow trees?	Yes □ No □
D10 Which species did you plant?	
D11 If so, why? If not, why not?	

THANK YOU VERY MUCH FOR YOUR HELP!

Appendix 5.1: Percentage of plots for different categories of site factors

		Watersheds I	II	III	IV	V	Entire forest
	Number of plots	51	65	150	131	103	500
Exposure	No exp	6	3	7	19	16	11
	NE	88	55	4	3	27	24
	NW	2	38	38	5	1	18
	SE	4	2	7	30	39	19
	SW	0	2	44	43	17	28
Slope (degrees)	0	6	3	7	19	16	11
	1-20	35	38	46	37	37	40
	21-40	57	55	47	44	43	47
	>40	2	3	1	1	5	2
Main soil texture	sand	90	85	81	82	67	80
	silt	2	8	5	9	16	8
	loam	6	5	7	2	13	6
	rock	2	3	7	3	4	4
	rubble	0	0	0	4	1	1
Depth of soil (cm)	0-20	39	28	47	33	32	37
	21-40	61	68	51	60	65	59
	>40	0	5	2	8	3	4
Cover of rock (%)	0	6	6	11	18	18	13
	1-40	73	71	67	60	67	66
	41-80	18	18	12	18	12	15
	>80	4	5	10	4	3	6

Appendix 5.2: Species found in the Kadavakurichi Reserved Forest

Table 1: Watersheds except Temple Forest

Family	Botanical Name	Local Name	Life form regarding MATTHEW,
Acanthaceae	Barleria longiflora	Kurunji	Sub Shrub
	Blepharis maderaspatensis	/	Herb
	Lepidagathis spec.	/	Herb (o)
	Strobilanthes cuspidata	Kaunkurinji	Shrub
	Barleria cuspidata	Chilimullu	Sub Shrub
Agavaceae	Agave angustifolia	Karunkathalai	Herb
Aizoaceae	Mollugo cerviana	/	Herb
Amaranthaceae	Aerva lanata	Koolaipoo	Herb
	Pupalia lappacea	Ottupullu	Herb
Apocynaceae	Carissa spinarum	Kelsedi	Shrub
	Wrightia tinctoria	Palamaram	Tree
Bruseraceae	Commiphora berryi	Kiluvai	Shrub/Tree
	Commiphora caudata	Sengiluvai	Tree
Capparaceae	Cadaba fruticosa	Viluthi (M)	Shrub
	Capparis sepiaria	Indusedi	Straggler
	Cleome monophylla	/	Herb
	Cleome viscosa	/	Perennial Herb
Caryophyllaceae	Polycarpaea corymbosa	Pallipoondu	Herb
Celastraceae	Unidentified S05	/	Shrub (o)
Compositae	Notoria grandiflora	Mosakkathalai	Sub Shrub (o)
	Tridax procumbens	/	Herb
Convolvulaceae	Rivea hypocrateriformis	/	Vine
	Ipomoea indica	/	Perennial Herb
	Ipomoea staphylina	Oonankodi	permanent twinner or liane
	Ipomoea maxima	/	Herb (o)
Cordiaceae	Cordia obliqua	/	Tree
	Ehretia canarinsis	/	Tree (o)
Dioscoreaceae	Dioscorea pentaphylla	Kanvulikilangu	Vine
Ebenaceae	Diospyros ebenum	/	Tree
	Diospyros montana	/	Tree
Erythroxylaceae	Erythroxylum monogynum	/	Shrub
Euphorbiaceae	Euphorbia antiquorum	Kalli	Shrub/Tree
	Jatropha gossypiifolia	Athalai	Shrub
	Acalypha fruticosa	Cheenithalavu	Shrub
	Euphorbia hirta	/	Herb
	Euphorbia nivulia	Ilaikalli	Tree
	Euphorbia tirucalli	Vadha Kalli	Shrub/Tree
	Flueggea leucopyrus	Poolanchedi	Shrub
	Givotia moluccana	/	Tree
	Phyllanthus amarus	Keelanelli	Herb
Fabaceae	Abrus precatorius	Kundumani	Straggler
	Acacia chundra	/	Tree
	Acacia ferruginea	Parambai	Tree
	Acacia horrida	Kodaisal li	Tree
	Acacia leucophloea	/	Tree
	Acacia planifrons	Salli	Tree
	Acacia spec. 1	/	Tree (o)

Family	Botanical Name	Local Name	Life form regarding MATTHEW,
Fabaceae	Albizia amara	Usilai	Tree
	Albizia lebbeck	Vagai	Tree
	Bauhinia racemosa	/	Tree
	Cassia auriculata	Aavarai	Shrub
	Crotalaria calycina	/	Herb
	Crotalaria trifoliastrum	/	Sub Shrub
	Desmodium alysicarpoides	/	Herb
	Dichrostachys cinerea	/	Shrub/Tree
	Erythrina suberosa	Mul Murungai	Tree
	Mundulea sericea	Venpurasu	Shrub
	Pongamia glabra	Pongamaram	Tree
	Prosopis juliflora	Karuvalamaram	Tree
	Pterocarpus santalinus	Santhana Vengai	Tree
	Pterolobium hexapetalum	Indu	Straggler
	Tamarindus indica	Pulimaram	Tree
	Tephrosia villosa	/	Sub Shrub
	Tephrosia purpurea	Kolingi	Sub Shrub
Flacourtiaceae	Flacourtia indica	/	Shrub/Tree
Hernandiaceaea	Gyrocarpus americanus	Vandalai	Tree
Hyppocrateaceae	Loeseneriella obtusifolia	/	Straggler
	Sarmenilla obsticifolia	/	Climber (o)
Labiatae	Anisochilus argenteus	/	Sub Shrub
	Leucas aspera	Thumbai	Herb
	Ocimum canum	Naytulsi	Herb
	Ocimum tenuiflorum	Tulsi	Sub Shrub
	Orthosiphon thymiflorus	/	Sub Shrub
	Anisochilus carnosus	/	Annual Sub Shrub
Liliaceae	Asparagus racemosus	/	Vine
Loganiaceae	Strychnos potatorum	/	Tree
Malvaceae	Hibiscus micranthus	/	Sub Shrub
	Pavonia odorata	/	Sub Shrub
Meliaceae	Azadirachta indica	Veppamaram	Tree
Moraceae	Ficus mollis	Kallichi	Tree
Moringaceae	Moringa oleifera	Murungamaram	Tree
Myrtaceae	Syzygium cumini	Navalmaram	Tree
Ochnaceae	Ochna obtusata var. gamblei	/	Shrub/Tree
Oleaceae	Jasminum sessiliflorum	/	Straggler
	Jasminum trichotomum	/	Straggler
Pedaliaceae	Sesamum radiatum	/	Herb
Poaceae	Bothriochloa pertusa	/	Culms
	Brachiaria distachya	/	Culms
	Chrysopogon fulvus	/	Culms
	Cymbopogon spec.	/	Grass
	Digitaria longiflora	/	Culms
	Eragrostiella bifaria	/	Culms
	Eragrostis nigra	/	Culms
	Fimbristylis spec.	/	Grass (o)
	Heteropogon contortus	Kettipullu	Culms
	Themeda cymbaria	Poothaipull	Culms
	Unidentified G01	/	Grass (o)
	Unidentified G02	/	Grass (o)

Family	Botanical Name	Local Name	Life form regarding MATTHEW,
	Unidentified G03	/	Grass (o)
	Unidentified G04	/	Grass (o)
Poaceae	Unidentified G05	/	Grass (o)
	Unidentified G06	/	Grass (o)
	Unidentified G07	/	Grass (o)
	Unidentified G08	/	Grass (o)
	Unidentified G09	/	Grass (o)
	Unidentified G11	/	Grass (o)
Rhamnaceae	Scutia myrtina	/	Straggler
	Ziziphus mauritiana	Ilanthai	Tree
	Ziziphus oenoplia	Pulchampalam	Shrub/Tree
Rubiaceae	Canthium coromandelicum	Karachedi	Shrub
	Canthium dicoccum	/	Tree
	Catunaregam dumetorum	Madukarai	Shrub
	Coffea wightiana	/	Shrub
	Morinda coreia	Nuna/Manjalnetti	Shrub/Tree
	Oldenlandia umbellata	/	Herb
	Tarenna asiatica	/	Shrub/Tree
Rutaceae	Chloroxylon swietenia	Venpurasu	Tree
	Pleiospermium alatum	/	Shrub/Tree
Sapindaceae	Cardiospermum halicacabum	/	Vine
	Dodonaea angustifolia	Virali	Shrub
	Sapindus emarginata	/	Tree
Tiliaceae	Grewia abutilifolia	/	Shrub/Tree
	Grewia bracteata	Acha	Straggler/Tree
	Grewia hirsuta	/	Shrub
	Grewia spec.	/	Shrub (o)
	Grewia tenax	/	Shrub
	Grewia villosa	/	Shrub/Tree
Verbanaceae	Lantana wightiana	/	Sub Shrub
	Unidentified ST04	/	Tree
	Clerodendrum viscosum	/	Shrub
	Tectona grandis	Thekku	Tree
Vitaceae	Cissus quadrangularis	Pirandai	Shrub
Zygophyllaceae	Tribulus terrestris	/	Herb
Family unknown	Unidentified H01	/	Herb (o)
	Unidentified H02	/	Herb (o)
	Unidentified H03	/	Herb (o)
	Unidentified H04	/	Herb (o)
	Unidentified H05	/	Herb (o)
	Unidentified S01	/	Shrub (o)
	Unidentified S03	/	Shrub (o)
	Unidentified S04	/	Shrub (o)
	Unidentified SS01	/	Sub Shrub (o)
	Unidentified SS03	/	Sub Shrub (o)
	Unidentified SS04	/	Sub Shrub (o)
	Unidentified SS06	/	Sub Shrub (o)
	Unidentified SSS01	/	Sub Shrub (o)
	Unidentified ST01	/	Shrub/Tree (o)
	Unidentified ST02	/	Shrub/Tree (o)
	Unidentified ST03	/	Shrub/Tree (o)

o = others than MATTHEW

Table 2: Temple Forest

Family	Botanical Name	Local Name	Life form regarding MATTHEW,
Acanthaceae	Barleria longiflora	Kurunji	Sub Shrub
Apocynaceae	Wrightia tinctoria	Palamaram	Tree
Bruseraceae	Commiphora berryi	Kiluvai	Shrub/Tree
Capparaceae	Capparis sepiaria	Indusedi	Straggler
Ebenaceae	Diospyros ebenum	/	Tree
	Diospyros montana	/	Tree
Erythroxylaceae	Erythroxylum monogynum	/	Shrub
Euphorbiaceae	Drypetes sepiaria	/	Shrub/Tree
	Euphorbia antiquorum	Kalli	Shrub/Tree
	Flueggea leucopyrus	Poolanchedi	Shrub
Fabaceae	Albizia amara	Usilai	Tree
	Albizia lebbeck	Vagai	Tree
	Cassia auriculata	Aavarai	Shrub
	Pterolobium hexapetalum	Indu	Straggler
Hippocrateaceae	Sarmenilla obsticifolia	/	Climber (o)
Meliaceae	Azadirachta indica	Veppamaram	Tree
Oleaceae	Jasminum sessiliflorum	/	Straggler
	Jasminum trichotomum	/	Straggler
Poaceae	Themeda cymbaria	Poothaipull	Culms
Rubiaceae	Coffea wightiana	/	Shrub
Rutaceae	Pleiospermium alatum	/	Shrub/Tree
Sapindaceae	Lepisanthes tetraphylla	/	Tree
	Sapindus emarginata	/	Tree
Simaroubaceae	Ailanthus excelsa	Peenari	Tree

o = others than MATTHEW

Appendix 5.3: Frequency of plant species in the Kadavakurichi RF

Table 1: Watersheds (number and ratio of plots)

Type	BotanicalName	Entire Hillock		Watershed I		Watershed II		Watershed III		Watershed IV		Watershed V	
		No	%	No	%	No	%	No	%	No	%	No	%
Tree	Commiphora berryi	341	68	35	69	47	72	80	53	100	76	79	77
30 qm	Euphorbia antiquorum	273	55	23	45	30	46	83	55	90	69	47	46
	Acacia planifrons	73	15	7	14	12	18	21	14	17	13	16	16
	Acacia horrida	43	9	4	8	3	5	1	1	16	12	19	18
	Acacia spec. 1	39	8	2	4	-	-	8	5	16	12	12	12
	Dichrostachys cinerea	38	8	2	4	2	3	4	3	24	18	6	6
	Acacia ferruginea	34	7	4	8	6	9	16	11	5	4	3	3
	Albizia amara	27	5	3	6	3	5	8	5	6	5	7	7
	Wrightia tinctoria	21	4	2	4	3	5	4	3	5	4	7	7
	Ochna obtusata var. gamblei	13	3	3	6	-	-	4	3	3	2	3	3
	Acacia chundra	12	2	3	6	4	6	1	1	3	2	1	1
	Azadirachta indica	12	2	1	2	2	3	4	3	3	2	2	2
	Commiphora caudata	12	2	-	-	-	-	8	5	1	1	3	3
	Diospyros montana	12	2	1	2	2	3	5	3	-	-	4	4
	Ehretia canarinsis	12	2	-	-	4	6	4	3	3	2	1	1
	Tamarindus indica	12	2	3	6	2	3	-	-	4	3	3	3
	Acacia leucophloea	9	2	-	-	1	2	4	3	2	2	2	2
	Pleiospermium alatum	9	2	1	2	1	2	3	2	3	2	1	1
	Tarenna asiatica	9	2	-	-	1	2	4	3	2	2	2	2
	Ficus mollis	8	2	1	2	1	2	2	1	3	2	1	1
	Canthium dicoccum	7	1	1	2	2	3	4	3	-	-	-	-
	Gyrocarpus americanus	7	1	-	-	-	-	4	3	1	1	2	2
	Grewia abutilifolia	6	1	-	-	-	-	1	1	3	2	2	2
	Chloroxylon swietenia	4	1	2	4	-	-	1	1	-	-	1	1
	UnidentifiedST01	4	1	-	-	1	2	-	-	-	-	3	3
	Albizia lebbeck	3	1	-	-	-	-	-	-	1	1	2	2
	Diospyros ebenum	3	1	1	2	-	-	2	1	-	-	-	-
	Erythrina suberosa	3	1	-	-	2	3	1	1	-	-	-	-
	Pongamia glabra	3	1	2	4	-	-	1	1	-	-	-	-
	Ziziphus mauritiana	3	1	-	-	-	-	2	1	-	-	1	1
	Pterocarpus santalinus	2	<1	-	-	-	-	-	-	1	1	1	1
	Bauhinia racemosa	1	<1	1	2	-	-	-	-	-	-	-	-
	Cordia obliqua	1	<1	-	-	-	-	-	-	-	-	1	1
	Euphorbia nivulia	1	<1	-	-	-	-	-	-	-	-	1	1
	Euphorbia tirucalli	1	<1	-	-	-	-	1	1	-	-	-	-
	Givotia moluccana	1	<1	-	-	-	-	1	1	-	-	-	-
	Morinda coreia	1	<1	-	-	-	-	1	1	-	-	-	-
	Moringa oleifera	1	<1	-	-	-	-	-	-	1	1	-	-
	Prosopis juliflora	1	<1	-	-	-	-	1	1	-	-	-	-
	Sapindus emarginata	1	<1	1	2	-	-	-	-	-	-	-	-
	Strychnos potatorum	1	<1	1	2	-	-	-	-	-	-	-	-
	Syzygium cumini	1	<1	-	-	-	-	-	-	1	1	-	-
	Tectona grandis	1	<1	-	-	-	-	1	1	-	-	-	-
	Unidentified ST02	1	<1	-	-	-	-	-	-	-	-	1	1
	Unidentified ST03	1	<1	-	-	-	-	-	-	1	1	-	-
	Unidentified ST04	1	<1	-	-	-	-	1	1	-	-	-	-

Type	BotanicalName	Entire Hillock		Watershed									
				I		II		III		IV		V	
		No	%	No	%	No	%	No	%	No	%	No	%
Shrub	Flueggea leucopyrus	185	37	22	43	29	45	48	32	44	34	42	41
	Acalypha fruticosa	122	24	7	14	6	9	51	34	26	20	32	31
	Pterolobium hexapetalum (C)	102	20	12	24	3	5	39	26	20	15	28	27
	Jasminum trichotomum (C)	101	20	14	27	19	29	20	13	24	18	24	23
	Jasminum sessiliflorum (C)	95	19	9	18	16	25	26	17	25	19	19	18
	Capparis sepiaria (C)	87	17	8	16	7	11	29	19	17	13	26	25
	Catunaregam dumetorum	69	14	10	20	18	28	20	13	14	11	7	7
	Canthium coromandelicum	61	12	10	20	14	22	19	13	11	8	7	7
	Coffea wightiana	56	11	8	16	2	3	22	15	12	9	12	12
	Grewia tenax	56	11	6	12	3	5	21	14	13	10	13	13
	Ziziphus oenoplia	25	5	1	2	4	6	11	7	9	7	-	-
	Carissa spinarum	20	4	1	2	2	3	-	-	12	9	5	5
	Cassia auriculata	19	4	4	8	3	5	7	5	2	2	3	3
	Jatropha gossypiifolia	19	4	-	-	-	-	10	7	6	5	3	3
	Sarmenilla obsticifolia (C)	13	3	-	-	2	3	3	2	2	2	6	6
	Flacourtia indica	12	2	4	8	3	5	3	2	2	2	-	-
	Grewia villosa	12	2	1	2	-	-	4	3	4	3	3	3
	Grewia bracteata	11	2	1	2	2	3	4	3	1	1	3	3
	Abrus precatorius (C)	9	2	2	4	2	3	1	1	4	3	-	-
	Erythroxylum monogynum	8	2	1	2	3	5	1	1	1	1	2	2
	Unidentified S04	7	1	-	-	-	-	4	3	3	2	-	-
	Cadaba fruticosa	4	1	-	-	-	-	3	2	1	1	-	-
	Grewia hirsuta	4	1	-	-	1	2	-	-	1	1	2	2
	Unidentified SSS01	4	1	1	-	1	2	2	-	-	-	-	-
	Unidentified SSS01 (C)	4	1	1	2	1	2	2	1	-	-	-	-
	Ipomoea staphylina (C)	4	1	-	-	2	3	2	1	-	-	-	-
	Mundulea sericea	3	1	1	2	1	2	1	1	-	-	-	-
	Scutia myrtina (C)	3	1	-	-	-	-	2	1	-	-	1	1
	Grewia spec.	2	<1	-	-	-	-	2	1	-	-	-	-
	Clerodendrum viscosum	1	<1	-	-	-	-	-	-	1	1	-	-
	Dodonaea angustifolia	1	<1	-	-	1	2	-	-	-	-	-	-
	Loeseneriella obtusifolia	1	<1	-	-	-	-	-	-	1	1	-	-
	Unidentified S01	1	<1	1	2	-	-	-	-	-	-	-	-
	Unidentified S03	1	<1	-	-	-	-	1	1	-	-	-	-
	Unidentified S05	1	<1	-	-	-	-	1	1	-	-	-	-
Sub Shrub	Barleria longiflora	76	15	3	6	1	2	22	15	34	26	16	16
	Ocimum tenuiflorum	58	12	3	6	9	14	24	16	11	8	11	11
	Orthosiphon thymiflorus	38	8	3	6	8	12	18	12	7	5	2	2
	Hibiscus micranthus	21	4	1	2	-	-	12	8	1	1	7	7
	Tephrosia purpurea	18	4	1	2	-	-	5	3	9	7	3	3
	Unidentified SS01	17	3	4	8	3	5	2	1	-	-	8	8
	Anisochilus carnosus	12	2	-	-	-	-	-	-	12	9	-	-
	Barleria cuspidata	12	2	1	2	-	-	3	2	4	3	4	4
	Lantana wightiana	9	2	-	-	2	3	1	1	2	2	4	4
	Tephrosia villosa	6	1	-	-	1	2	2	1	-	-	3	3
	Notoria grandiflora	4	1	-	-	1	2	-	-	1	1	2	2
	Pupalia lappacea	4	1	-	-	-	-	1	1	-	-	3	3
	Pavonia odorata	3	1	-	-	-	-	1	1	1	1	1	1
	Unidentified SS04	3	1	-	-	-	-	3	2	-	-	-	-
	Unidentified SS06	2	<1	-	-	-	-	1	1	1	1	-	-
	Unidentified SS03	1	<1	-	-	-	-	1	1	-	-	-	-

(C) = Climber

Type	BotanicalName	Entire Hillock		Watershed I		Watershed II		Watershed III		Watershed IV		Watershed V	
		No	%	No	%	No	%	No	%	No	%	No	%
Grass	Chrysopogon fulvus	140	28	13	25	21	32	33	22	41	31	32	31
	Themeda cymbaria	134	27	16	31	27	42	41	27	18	14	32	31
	Heteropogon contortus	88	18	12	24	2	3	31	21	22	17	21	20
	Unidentified G03	10	2	2	4	6	9	2	1	-	-	-	-
	Unidentified G07	9	2	3	6	2	3	3	2	-	-	1	1
	Eragrostiella bifaria	6	1	-	-	-	-	3	2	-	-	3	3
	Unidentified G04	6	1	-	-	2	3	4	3	-	-	-	-
	Unidentified G02	5	1	-	-	3	5	1	1	1	1	-	-
	Bothriochloa pertusa	4	1	-	-	-	-	2	1	-	-	2	2
	Eragrostis nigra	4	1	3	6	-	-	-	-	-	-	1	1
	Unidentified G08	4	1	2	4	1	2	-	-	-	-	1	1
	Brachiaria distachya	3	1	1	2	-	-	1	1	-	-	1	1
	Digitaria longiflora	2	<1	2	4	-	-	-	-	-	-	-	-
	Fimbristylis spec.	2	<1	-	-	-	-	1	1	-	-	1	1
	Unidentified G06	2	<1	-	-	-	-	1	1	-	-	1	1
	Unidentified G09	2	<1	1	2	1	2	-	-	-	-	-	-
	Unidentified G01	1	<1	-	-	-	-	1	1	-	-	-	-
	Unidentified G05	1	<1	-	-	-	-	1	1	-	-	-	-
	Unidentified G11	1	<1	-	-	-	-	-	-	-	-	1	1
Herb	Ocimum canum	42	8	2	4	4	6	20	13	10	8	6	6
	Strobilanthes cuspidata	23	5	4	8	1	2	9	6	-	-	9	9
	Lepidagathis spec.	22	4	1	2	1	2	2	1	17	13	1	1
	Cissus quadrangularis	17	3	2	4	-	-	5	3	5	4	5	5
	Unidentified H02	16	3	-	-	1	2	5	3	4	3	6	6
	Cardiospermum halicacabum	14	3	1	2	-	-	6	4	4	3	3	3
	Leucas aspera	13	3	-	-		<1	5	3	5	4	3	3
	Blepharis maderaspatensis	12	2	1	2	1	2	4	3	3	2	3	3
	Anisochilus argenteus	9	2	-	-	-	-	3	2	6	5	-	-
	Cleome viscosa	5	1	2	4	-	-	-	-	2	2	1	1
	Crotalaria trifoliastrum	5	1	-	-	3	5	1	1	-	-	1	1
	Aerva lanata	4	1	-	-	-	-	1	1	1	1	2	2
	Cymbopogon spec.	3	1	-	-	-	-	1	1	1	1	1	1
	Euphorbia hirta	3	1	-	-	-	-	1	1	-	-	2	2
	Phyllanthus amarus	3	1	-	-	-	-	2	1	-	-	1	1
	Rivea hypocrateriformis	3	1	1	2	-	-	-	-	1	1	1	1
	Unidentified H01	3	1	1	2	-	-	-	-	-	-	2	2
	Asparagus racemosus	2	<1	-	-	1	2	-	-	-	-	1	1
	Ipomoea indica	2	<1	-	-	-	-	1	1	-	-	1	1
	Oldenlandia umbellata	2	<1	-	-	1	2	-	-	1	1	-	-
	Tridax procumbens	2	<1	-	-	-	-	1	1	-	-	1	1
	Agave angustifolia	1	<1	-	-	-	-	-	-	1	1	-	-
	Cleome monophylla	1	<1	-	-	-	-	1	1	-	-	-	-
	Crotalaria calycina	1	<1	-	-	-	-	-	-	-	-	1	1
	Desmodium alysicarpoides	1	<1	-	-	-	-	-	-	-	-	1	1
	Dioscorea pentaphylla	1	<1	-	-	-	-	1	1	-	-	-	-
	Ipomoea maxima	1	<1	-	-	-	-	-	-	1	1	-	-
	Mollugo cerviana	1	<1	-	-		<1	-	-	-	-	1	1
	Polycarpaea corymbosa	1	<1	-	-	-	-	-	-	1	1	-	-
	Sesamum radiatum	1	<1		<1	-	-	1	1	-	-	-	-
	Tribulus terrestris	1	<1	-	-	-	-	1	1	-	-	-	-
	Unidentified H03	1	<1	-	-	-	-	-	-	1	1	-	-
	Unidentified H04	1	<1	-	-	-	-	-	-	-	-	1	1
	Unidentified H05	1	<1	-	-	-	-	1	1	-	-	-	-

Table 2: Temple Forest (number of plots)

Phenotype	Species	No of plots
Tree	Lepisanthes tetraphylla	6
	Albizia amara	2
	Commiphora berryi	2
	Diospyros ebenum	2
	Pleiospermium alatum	2
	Sapindus emarginata	2
	Ailanthus excelsa	1
	Atalantia monophylla	1
	Azadirachta indica	1
	Diospyros montana	1
	Drypetes sepiaria	1
	Euphorbia antiquorum	1
	Wrightia tinctoria	1
Shrub	Flueggea leucopyrus	5
	Coffea wightiana	4
	Sarmenilla obsticifolia (C)	4
	Capparis sepiaria (C)	2
	Jasminum sessiliflorum (C)	2
	Jasminum trichotomum (C)	2
	Cassia auriculata	1
	Erythroxylum monogynum	1
	Pterolobium hexapetalum (C)	1
Sub Shrub	Barleria longiflora	1
	Unidentified SS04	1
Grass	Themeda cymbaria	2

C = Climber

Appendix 5.4: Species distribution over cover classes

Table 1: Watersheds

	Cover Classes					
	1-20%	21-40%	41-60%	61-80%	81-100%	total
Trees						
Commiphora berryi	152	41	21	13	7	234
Euphorbia antiquorum	109	43	17	6	2	177
Acacia planifrons	25	10	9	6	5	55
Acacia horrida	17	6	6	1	2	32
Dichrostachys cinerea	19	4	-	-	-	23
Acacia spec. 1	17	1	2	-	2	22
Acacia ferruginea	11	2	1	2	-	16
Wrightia tinctoria	10	-	-	-	-	10
Acacia chundra	9	-	-	-	-	9
Ochna obtusata var. gamblei	9	-	-	-	-	9
Albizia amara	6	2	-	-	-	8
Commiphora caudata	3	1	2	2	-	8
Diospyros montana	8	-	-	-	-	8
Ficus mollis	3	2	-	1	2	8
Pleiospermium alatum	4	3	-	-	-	7
Grewia abutilifolia	6	-	-	-	-	6
Tarenna asiatica	5	-	-	1	-	6
Azadirachta indica	4	-	-	1	-	5
Gyrocarpus americanus	3	1	-	1	-	5
Acacia leucophloea	4	-	-	-	-	4
Ehretia canarinsis	4	-	-	-	-	4
Canthium dicoccum	3	-	-	-	-	3
Erythrina suberosa	2	1	-	-	-	3
Pongamia glabra	3	-	-	-	-	3
Tamarindus indica	3	-	-	-	-	3
Unidentified ST01	2	1	-	-	-	3
Ziziphus mauritiana	3	-	-	-	-	3
Albizia lebbeck	2	-	-	-	-	2
Diospyros ebenum	2	-	-	-	-	2
Pterocarpus santalinus	2	-	-	-	-	2
Bauhinia racemosa	1	-	-	-	-	1
Cordia obliqua	-	1	-	-	-	1
Euphorbia tirucalli	1	-	-	-	-	1
Givotia moluccana	1	-	-	-	-	1
Moringa oleifera	1	-	-	-	-	1
Sapindus emarginata	1	-	-	-	-	1
Strychnos potatorum	1	-	-	-	-	1
Tectona grandis	1	-	-	-	-	1
Unidentified ST02	1	-	-	-	-	1
Unidentified ST03	-	1	-	-	-	1

Species which only appeared in the 30 m² plots

Chloroxylon swietenia
Morinda coreia
Prosopis juliflora
Syzygium cumini
Unidentified ST04
Euphorbia nivulia

	Cover Classes					
	1-20%	21-40%	41-60%	61-80%	81-100%	total
Shrub						
Flueggea leucopyrus	174	11	1	-	-	186
Acalypha fruticosa	115	6	1	-	-	122
Pterolobium hexapetalum (C)	63	15	16	8	-	102
Jasminum trichotomum (C)	94	5	2	-	-	101
Jasminum sessiliflorum (C)	93	1	1	-	-	95
Capparis sepiaria (C)	82	4	1	-	-	87
Catunaregam dumetorum	57	10	1	1	-	69
Canthium coromandelicum	48	9	3	1	-	61
Coffea wightiana	51	4	1	-	-	56
Grewia tenax	52	3	1	-	-	56
Ziziphus oenoplia	16	6	3	-	-	25
Carissa spinarum	13	5	2	-	-	20
Cassia auriculata	18	1	-	-	-	19
Jatropha gossypiifolia	17	2	-	-	-	19
Sarmenilla obsticifolia (C)	11	1	-	1	-	13
Flacourtia indica	9	2	1	-	-	12
Grewia villosa	10	2	-	-	-	12
Grewia bracteata	9	1	1	-	-	11
Abrus precatorius (C)	8	1	-	-	-	9
Erythroxylum monogynum	6	1	1	-	-	8
Unidentified S04	7	-	-	-	-	7
Cadaba fruticosa	4	-	-	-	-	4
Unidentified SSS01	4	-	-	-	-	4
Grewia hirsuta	3	-	1	-	-	4
Ipomoea staphylina (C)	3	1	-	-	-	4
Mundulea sericea	2	1	-	-	-	3
Scutia myrtina (C)	3	-	-	-	-	3
Grewia spec.	2	-	-	-	-	2
Clerodendrum viscosum	1	-	-	-	-	1
Dodonaea angustifolia	-	1	-	-	-	1
Loeseneriella obtusifolia	-	-	-	1	-	1
Unidentified S01	1	-	-	-	-	1
Unidentified S03	1	-	-	-	-	1
Unidentified S05	-	-	-	1	-	1
SubShrub						
Barleria longiflora	63	10	3	-	-	76
Ocimum tenuiflorum	57	1	-	-	-	58
Orthosiphon thymiflorus	37	1	-	-	-	38
Hibiscus micranthus	21	-	-	-	-	21
Tephrosia purpurea	17	1	-	-	-	18
Unidentified SS01	17	-	-	-	-	17
Anisochilus carnosus	12	-	-	-	-	12
Barleria cuspidata	12	-	-	-	-	12
Lantana wightiana	8	1	-	-	-	9
Tephrosia villosa	6	-	-	-	-	6
Notoria grandiflora	4	-	-	-	-	4
Pupalia lappacea	4	-	-	-	-	4
Pavonia odorata	3	-	-	-	-	3
Unidentified SS04	3	-	-	-	-	3
Unidentified SS06	2	-	-	-	-	2
Unidentified SS03	1	-	-	-	-	1

	Cover Classes					
	1-20%	21-40%	41-60%	61-80%	81-100%	total
Grass						
Chrysopogon fulvus	107	22	7	4	-	140
Themeda cymbaria	74	34	15	8	3	134
Heteropogon contortus	62	16	6	4	-	88
Unidentified G03	5	2	2	1	-	10
Unidentified G07	9	-	-	-	-	9
Eragrostiella bifaria	6	-	-	-	-	6
Unidentified G04	5	1	-	-	-	6
Unidentified G02	5	-	-	-	-	5
Eragrostis nigra	3	1	-	-	-	4
Unidentified G08	2	1	1	-	-	4
Bothriochloa pertusa	-	4	-	-	-	4
Brachiaria distachya	2	1	-	-	-	3
Digitaria longiflora	1	1	-	-	-	2
Fimbristylis spec.	2	-	-	-	-	2
Unidentified G06	2	-	-	-	-	2
Unidentified G09	2	-	-	-	-	2
Unidentified G01	1	-	-	-	-	1
Unidentified G05	1	-	-	-	-	1
Unidentified G11	1	-	-	-	-	1
Herb						
Ocimum canum	39	3	-	-	-	42
Strobilanthes cuspidata	19	3	-	1	-	23
Lepidagathis spec.	21	1	-	-	-	22
Cissus quadrangularis	17	-	-	-	-	17
Unidentified H02	13	3	-	-	-	16
Cardiospermum halicacabum	13	1	-	-	-	14
Leucas aspera	13	-	-	-	-	13
Blepharis maderaspatensis	11	1	-	-	-	12
Anisochilus argenteus	9	-	-	-	-	9
Cleome viscosa	5	-	-	-	-	5
Crotalaria trifoliastrum	5	-	-	-	-	5
Aerva lanata	4	-	-	-	-	4
Cymbopogon spec.	3	-	-	-	-	3
Euphorbia hirta	3	-	-	-	-	3
Phyllanthus amarus	3	-	-	-	-	3
Rivea hypocrateriformis	3	-	-	-	-	3
Unidentified H01	3	-	-	-	-	3
Asparagus racemosus	2	-	-	-	-	2
Ipomoea indica	2	-	-	-	-	2
Oldenlandia umbellata	1	1	-	-	-	2
Tridax procumbens	2	-	-	-	-	2
Agave angustifolia	-	-	1	-	-	1
Cleome monophylla	1	-	-	-	-	1
Crotalaria calycina	1	-	-	-	-	1
Desmodium alysicarpoides	1	-	-	-	-	1
Dioscorea pentaphylla	1	-	-	-	-	1
Ipomoea maxima	1	-	-	-	-	1
Mollugo cerviana	1	-	-	-	-	1
Polycarpaea corymbosa	1	-	-	-	-	1
Sesamum radiatum	1	-	-	-	-	1
Tribulus terrestris	1	-	-	-	-	1
Unidentified H03	1	-	-	-	-	1
Unidentified H04	1	-	-	-	-	1
Unidentified H05	1	-	-	-	-	1

Table 2: Temple Forest

	Cover Classes					
	1-20%	21-40%	41-60%	61-80%	81-100%	total
Tree						
Lepisanthes tetraphylla	-	-	-	2	2	4
Diospyros ebenum	2	-	-	-	-	2
Pleiospermium alatum	-	1	-	1	-	2
Sapindus emarginata	2	-	-	-	-	2
Ailanthus excelsa	-	-	1	-	-	1
Albizia amara	1	-	-	-	-	1
Atalantia monophylla	-	-	-	1	-	1
Azadirachta indica	1	-	-	-	-	1
Commiphora berryi	1	-	-	-	-	1
Diospyros montana	1	-	-	-	-	1
Euphorbia antiquorum	1	-	-	-	-	1
Wrightia tinctoria	-	1	-	-	-	1
Shrub						
Flueggea leucopyrus	5	-	-	-	-	5
Coffea wightiana	4	-	-	-	-	4
Sarmenilla obsticifolia (C)	4	-	-	-	-	4
Cassia auriculata	1	1	-	-	-	2
Capparis sepiaria	2	-	-	-	-	2
Jasminum sessiliflorum (C)	2	-	-	-	-	2
Jasminum trichotomum (C)	2	-	-	-	-	2
Erythroxylum monogynum	1	-	-	-	-	1
Pterolobium hexapetalum (C)	1	-	-	-	-	1
Sub Shrub						
Barleria longiflora	1	-	-	-	-	1
Unidentified SS04	1	-	-	-	-	1
Grass						
Themeda cymbaria	1	1	-	-	-	2

(C) = Climber

Appendix 5.5: Soziodemographic data

Table 1: Distribution of cattle numbers to user and non-user households

Cattle	Number	Non Users	Users	Cattle	Number	Non-Users	Users
Goat	1	15	9	Cow	1	21	17
	2	9	4		2	20	11
	3	2	2		3	5	2
	4	1	5		4	1	1
	5	1	2		5	1	0
	6	1	1				
	7	1	4	Sheep	2	2	3
	10	1	7		3	1	1
	15	-	5		5	-	1
	20	-	4		10	1	1
	22	-	1		20	-	4
	23	-	1		30	-	2
	30	-	1		40	-	1
	35	-	1	Buffalo	5	1	0
	40	-	1				
				Dung cattle	3	-	1
Bullock	1	-	1		12	-	1
	2	10	8		15	-	1
	3	3	2		18	-	1

Table 2: Main profession of the questioned people among the users of the different watersheds in %

Profession	WS				
	I	II	III	IV	V
Coolie	49	44	64	40	35
farmer	7	39	4	30	38
small scale mercantilist	13	11	3	0	3
school child	0	0	12	0	0
Fuelwood cutter	13	0	2	0	3
herdsmen	2	6	4	20	6
honey collector	0	0	8	0	0
employee	0	0	2	0	3
worker	2	0	1	0	3
driver	4	0	0	0	0
mason	2	0	0	0	3
artist	2	0	0	0	0
electrician	0	0	0	10	0
forest user	2	0	0	0	0
tailor	0	0	1	0	0
housewife	5	0	0	0	6
Total Number	55	18	105	10	34

Table 3: Main profession of the questioned people among the non-users of the different watersheds in %

Profession	WS				
	I	II	III	IV	V
Coolie	22	33	40	38	29
Farmer	13	29	23	27	41
Small scale mercantilist	23	21	26	17	18
Astrologer	15	0	0	0	0
Worker	7	0	5	2	0
Carpenter	2	0	2	0	0
Employee	1	0	0	2	3
Mason	1	0	0	0	3
Retired	1	4	0	0	0
Driver	0	0	0	0	3
Electrician	1	0	0	0	0
Forest contractor	0	0	2	0	0
Herdsmen	1	0	0	0	0
Photographer	1	0	0	0	0
Teacher	1	0	0	0	0
Housewife	13	13	2	15	3
Total Number	102	24	43	48	34

Table 4: Number of named reasons for planting trees

Cluster	User	Non-user
Generating income	19	23
Support through institutions	15	5
Own consumption	10	13
Don’t know	3	3
Own consumption and shadow	3	1
Generating income and shadow	3	0
Generating income and own consumption	2	8
Generating income and because of support	2	2
Plantation came from natural regeneration	1	0
Timber	0	4
To get rain, shadow and cooling	0	8
Others	0	6
sum	58	73

Table 5: Number of named reasons not to plant trees

Cluster	Users	Non-users
No water	22	27
Land is under agricultural use	14	19
Land is leased to somebody	4	4
No support	4	2
Don’t know	3	0
Trees prevent cultivation of other crops	3	0
Natural regeneration exists	2	0
No answer	2	0
Land is wasteland	1	4
Cultivation of trees was a failure	1	3
Just bought the land	1	2
Takes too long to get benefit	1	0
Planting trees is useless	1	0
No space for trees	0	3
Can’t afford it	0	2
Others	0	4
Sum	59	70

Appendix 5.6: Soziodemographic data in dependence of forest product use

Table 1: Percentage of casts

	Fuelwood	Grazing	Green Manure	Honey	Medical Plants	Fence Material	Hunting	Thatching	Small Timber	Roots	No Response	Total
Moopar	59	48	4	89	92	89	100	89	100	100	29	58
Nayakkar	18	33	17	-	-	-	-	11	-	-	53	19
Thevar	10	12	8	6	-	-	-	-	-	-	12	8
Sakiliar	8	3	-	6	-	11	-	-	-	-	-	5
Naidu	-	-	33	-	-	-	-	-	-	-	-	3
Chettiar	-	-	25	-	-	-	-	-	-	-	-	2
Maniar	3	-	-	-	8	-	-	-	-	-	6	2
Pallar	2	3	4	-	-	-	-	-	-	-	-	2
Barber	-	-	8	-	-	-	-	-	-	-	-	1
Parayan	1	-	-	-	-	-	-	-	-	-	-	< 1
Sum	100	100	100	100	100	100	100	100	100	100	100	100

Table 2: Number of questioned persons according to age groups

	Fuelwood	Grazing	Green Manure	Honey	Medical Plants	Fence Material	Thatching	Small Timber	Hunting	Roots	No Response
<14	1	1	-	-	10	-	-	-	-	-	-
14-18	3	3	-	-	2	-	-	-	-	-	-
19-30	61	9	8	12	1	4	4	3	1	-	7
31-40	47	5	11	5	-	2	2	1	-	1	6
41-50	15	11	2	1	-	1	2	1	1	-	2
51-60	15	3	3	-	-	2	1	-	-	-	2
>60	1	1	-	-	-	-	-	-	-	-	-
No response	1	-	-	-	-	-	-	-	-	-	-
Sum	144	33	24	18	13	9	9	5	2	1	17

Table 3: Gender of persons involved in forest utilisation for the different uses

Gender of questioned person	Users involved in utilising of forest products	Firewood	Grazing	Green Manure	Honey	Medical Plants	Fence Material	Thatching	Small Timber	Hunting	Roots	No response
Female	self	34	10	20	-	2	1	3	-	-	-	6
	female	3	-	3	-	1	-	-	-	-	-	-
	male	4	3	-	-	-	-	-	-	-	-	-
	everybody	-	1	-	-	-	-	-	-	-	-	-
	children	-	-	-	-	2	-	-	-	-	-	-
Male	self	110	23	4	18	1	8	6	5	2	1	11
	female	14	6	1	-	1	-	2	-	-	-	-
	male	5	7	-	2	-	1	-	-	-	-	-
	everybody	-	-	-	-	-	-	-	-	-	-	-
	children	-	-	-	-	-	-	-	-	-	-	-
Children (<14)	self	1	1	-	-	10	-	-	-	-	-	-
	female	14	6	-	-	1	-	-	-	-	-	-
	male	5	7	-	-	-	-	-	-	-	-	-
	everybody	-	-	-	-	-	-	-	-	-	-	-
	children	-	-	-	-	6	-	-	-	-	-	-
Sum	**female**	**51**	**16**	**24**	**-**	**3**	**1**	**5**	**-**	**-**	**-**	6
	male	**119**	**33**	**4**	**20**	**1**	**9**	**6**	**5**	**2**	**1**	**11**
	children	**20**	**14**	**-**	**-**	**18**	**-**	**-**	**-**	**-**	**-**	-

Appendix 5.7: Planted tree species and their main use

Scientific name	Local name	Uses (first is main one)	Number of mentioning users	non-users	total
Cocos nucifera	Thennai	fruit	28	42	70
Tectona grandis	Thekku	timber	29	24	53
Azadirachta indica	Veppamaram	medicinal, fruit, fodder, green manure, timber	26	26	52
Mangifera indica	Mamaram	fruit	3	11	14
Albizia lebbeck	Vagai	timber, medicinal	3	10	13
Gmelina arborea	Kumul	timber	1	11	12
Moringa oleifera	Murungai	Fruit, fodder	5	4	9
Psidium guajava	Koiya	fruit	3	6	9
Tamarindus indica	Puli	fruit, oil, timber	6	3	9
Casuarina equisetifolia	Savukku	timber, fuelwood	5		5
Ceiba pentandra	Ilavam	fruit	2	3	5
Albizia amara	Usilamaram	timber, fuelwood ?	2	2	4
Citrus limon	Elumichai	fruit	2	2	4
Dalbergia latifolia	Thothakathi	timber	3	1	4
Manilkara zapota	Sapota	fruit		4	4
Pithecellobium dulce	Kodikkapulli	fruit	3	1	4
Prosopis juliflora	Seemaikaruvelam	fuelwood, timber	3	1	4
Syzygium cumini	Naval	fruit, timber ?	2	2	4
Artocarpus heterophyllus	Pala	fruit	1	2	3
Bambusa arundinacea	Moongil	small timber	3		3
Cassia siamea	Manjakonnai	timber, fuelwood ?	2		2
Carica papaya	Papali	fruit		2	2
Emblica officinalis	Nelli	fruit	1	1	2
Eucalyptus spec.	Kunkulimaram	timber		2	2
Leucaena leucocephala	Suva Pullu	fodder, fuelwood	2	2	2
Morinda coreia	Manjalnethi	timber		2	2
Acacia nilotica	Karuvelam	?	1		1
Ailanthus excelsa	Pinaari	medicinal, fodder	1		1
Borassus flabellifer	Panaimaram	fruit	1		1
Caesalpinia pulcherrima	Mayil Konnai	?		1	1
Commiphora berryi	Kiluvai	fuelwood	1		1
Dalbergia sissoo	Sissoo	timber	1		1
Guettarda speciosa	Panneermaram	?		1	1
Phyllanthus acidus (?)	Nelli	?	1		1
Pterocarpus marsupium	Vengai	Timber, medicinal, oil		1	1
Wrightia tinctoria	Palamaram	green manure, fuelwood, timber		1	1
unknown			1		1

Appendix 5.8: Named plant species for the different uses

Phenotype	Species	Fuelwood	Grazing	Green Manure	Honey	Medical Plants	Fence Material	Grass (Roof)	Small Timber	Hunting	Roots	**Total**
		use										
Tree	Commiphora berryi	128	12	-	-	-	2	-	3	-	-	**145**
	Euphorbia antiquorum	101	1	-	-	-	-	-	1	-	-	**103**
	Acacia planifrons	21	2	-	-	-	-	-	-	-	-	**23**
	Wrightia tinctoria	3	-	11	-	-	-	-	-	-	-	**14**
	Acacia horrida	12	2	-	-	-	-	-	-	-	-	**14**
	Commiphora caudata	8	1	-	-	-	1	-	1	-	-	**11**
	Albizia amara	8	-	-	-	-	-	-	-	-	-	**8**
	Azadirachta indica	5	1	1	-	-	-	-	-	-	-	**7**
	Ficus mollis	4	-	-	-	-	-	-	-	-	-	**4**
	Pleiospermium alatum	3	1	-	-	-	-	-	-	-	-	**4**
	Erythrina suberosa	1	-	-	-	-	-	-	2	-	-	**3**
	Ailanthus excelsa	2	-	-	-	-	-	-	-	-	-	**2**
	Chloroxylon swietenia	1	-	-	-	-	-	-	1	-	-	**2**
	Tectona grandis	2	-	-	-	-	-	-	-	-	-	**2**
	Unknown species 2	-	-	-	-	-	-	-	2	-	-	**2**
	Dalbergia latifolia	-	-	-	-	-	-	-	1	-	-	**1**
	Albizia lebbeck	1	-	-	-	-	-	-	-	-	-	**1**
	Anogeissus latifolia	1	-	-	-	-	-	-	-	-	-	**1**
	Morinda coreia	-	-	1	-	-	-	-	-	-	-	**1**
	Prosopis juliflora	-	1	-	-	-	-	-	-	-	-	**1**
	Pterocarpus santalinus	1	-	-	-	-	-	-	-	-	-	**1**
	Unidentyfied T01	1	-	-	-	-	-	-	-	-	-	**1**
	Ziziphus mauritiana	1	-	-	-	-	-	-	-	-	-	**1**
Tree sum		304	21	13	-	-	3	-	11	-	-	**352**
others	Grass	-	11	-	-	-	-	1	-	-	-	**12**
	all plants	-	8	-	-	-	-	-	-	-	-	**8**
	all woody plants	4	1	-	-	-	-	-	-	-	-	**5**
	others	1	-	1	-	-	-	-	-	-	-	**2**
	all herbal plants	-	-	1	-	-	-	-	-	-	-	**1**
	keine	-	-	-	1	-	-	-	-	-	-	**1**
Other sum		5	20	2	1	-	-	-	-	-	-	**29**
others than	rabbit	-	-	-	-	-	-	-	-	4	-	**4**
plants	wild cat	-	-	-	-	-	-	-	-	1	-	**1**
Sum		-	-	-	-	-	-	-	-	5	-	5

		use										
Phenotype	Species	Fuelwood	Grazing	Green Manure	Honey	Medical Plants	Fence Material	Roof Material	Small Timber	Hunting	Roots	**Total**
Shrub	Flueggea leucopyrus	24	9	-	-	-	7	-	-	-	-	**40**
	Pterolobium hexapetalum	29	4	-	-	-	-	-	-	-	-	**33**
	Catunaregam dumetorum	27	3	-	-	-	2	-	-	-	-	**32**
	Acalypha fruticosa	1	6	15	-	-	-	-	-	-	-	**22**
	Cassia auriculata	1	-	12	-	-	-	-	-	-	-	**13**
	Jasminum sessiliflorum	-	7	-	-	-	-	-	-	-	-	**7**
	Calotropis gigantea	1	2	3	-	-	-	-	-	-	-	**6**
	Dalbergia horrida	1	-	-	-	-	5	-	-	-	-	**6**
	Grewia bracteata	3	3	-	-	-	-	-	-	-	-	**6**
	Carissa spinarum	4	1	-	-	-	-	-	-	-	-	**5**
	Dodonaea angustifolia	1	-	1	-	-	-	-	-	-	-	**2**
	Flacourtia indica	2	-	-	-	-	-	-	-	-	-	**2**
	Jasminum trichotomum	1	1	-	-	-	-	-	-	-	-	**2**
	Canthium coromandelicum	1	-	-	-	-	-	-	-	-	-	**1**
	Coffea wightiana		-	-	-	-	1	-	-	-	-	**1**
	Unbekannte Art 1	1	-	-	-	-	-	-	-	-	-	**1**
	Ziziphus oenoplia	1	-	-	-	-	-	-	-	-	-	**1**
Shrub sum		98	36	31	0	0	15	0	0	0	0	**180**
Grass	Themeda cymbaria	-	1	-	-	-	1	7	-	-	-	**9**
	Heteropogon contortus	-	2	-	-	-	-	1	-	-	-	**3**
Grass sum		-	3	-	-	-	1	8	-	-	-	**12**
Sub Shrub	Orthosiphon thymiflorus	-	2	17	-	13	-	-	-	-	-	**32**
	Tephrosia purpurea	-	-	19	-	-	-	-	-	-	-	**19**
	Barleria longiflora	2	2	3	-	2	-	-	-	-	-	**9**
	Ocimum tenuiflorum	-	-	-	-	3	-	-	-	-	-	**3**
Sub Shrub sum		2	4	39	-	18	-	-	-	-	-	**63**
Herb	Strobilanthes cuspidata	1	-	3	-	-	-	-	-	-	-	**4**
	Rivea hypocrateriformis	1	2	-	-	-	-	-	-	-	-	**3**
	Leucas aspera	1	1	-	-	-	-	-	-	-	-	**2**
	Dioscorea oppositifolia	-	-	-	-	-	-	-	-	-	1	**1**
Herb sum		3	3	3	-	-	-	-	-	-	-	**9**

Appendix 5.9: Number of grazed herds and cattle in the different watersheds

	WS	Number of cattle per herd >20	11-20	< 11	Sum of herds	Number of cattle
Goat	I	1	1	2	4	69
	II	0	2	1	3	46
	III	0	4	5	9	104
	IV	1	1	0	2	38
	V	2	2	2	6	112
	total	4	10	10	24	369
Sheep	I	1	0	0	1	30
	II	2	0	0	2	90
	III	0	3	1	4	70
	IV	1	1	0	2	50
	V	0	0	0	0	0
	total	4	4	1	9	240
Dung Cattle	I	1	0	0	1	18
	II	0	0	0	0	0
	III	0	1	0	1	15
	IV	0	0	0	0	0
	V	0	0	0	0	0
	total	1	1		2	33
Sum total		9	15	11	35	642