FARMING LIKE THE FOREST

Traditional Home Garden Systems in Sri Lanka

Karin Hochegger

Tropical Agroecology 191

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Drawings by Shanta Jayaweera

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View of a typical forest garden *(gewatta)*, Kandy District:
harvested rice fields in the foreground into a home garden
with ceremonial decoration of coconut palm leaves (Karin Hochegger)

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FOREWORD

The world driven to be 'developed' is racing to 'produce' more through the process of identifying a few species that will help to achieve the required 'increments'. This exercise has resulted in the past and is perpetuated in the present, with an even greater impetus by creating extensive plantation land areas with single species. This is the mainstay of the human needs, be it food, timber or industry. The resulting effort has caused untold hardships to mother-earth, which its most destructive inhabitant - man - seems to accept as inevitable and a price to pay for development.

Among these were a few mavericks who realized that the path taken would inevitably result in a conflict of interest. They sounded the warnings, which were laughed upon by many, they watched the sane practices slowly fade away. During the last 30 years we have seen how this conflict has unfolded itself gradually and has today become a concern- if not the major concern.

Searching among the traditional time tested practices has been one way of seeking remedies for the resolution of the conflict. It is here that the importance of the "*gewatta*" comes into play. In many locations, the " gewatta" still reflects the "time tested traditional" concept in full. It is this that is investigated and presented by the authors as a model for sustainable land use, while retaining as much biodiversity in perfect harmony in human settlements.

The present use of the term biodiversity clearly indicates that, the concern for its "conservation and sustainable use" has to look outside the traditional protected areas and wildlife conservation to ensure a much wider protection of biodiversity organisms than the few flagged species of yesterday. A "*gewatta*" is a unique model for such an approach.

The author has very fluently re-established the importance, the uniqueness of this system and presented quite professionally a case for considering this system as a substitute for the present settlements. It provides without doubt, a "retreat" away from the hustle and bustle of cities where man still seeks solace for survival through employment. This is a reality that one cannot run-away from. The *gewatta* provides serenity, products and engagement at a very high level. The promotion of the *gewatta* would without doubt pave the way for a society that is 'totally engaged' rather than employed and yet not content.

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At this point I would like to mention the Department of Botany, University of Peradeniya. The entire staff has always supported our work with assistance, advice and sometimes a cup of tea. The experience of working with the students of the University of Peradeniya was unforgettable. I want to express my grateful recognition for all the help I have received from them. Vihanga Pahalawatte, who has helped us with the preparation of soil samples and with laboratory work; her highly organised way of working formed a valuable contribution to our research group; S.P. Ekanayake, who contributed many valuable suggestions to the project through his expertise in Botany and Ecology ; S.Harisschandran, who was the most reliable counterpart in all our field

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Apart from that I want to express my appreciation for the hospitality and genuine friendliness I experienced during my work in Sri Lanka. The university staff as well as the students and the rural population, all of them have treated me with obliging openness and frankness, a typical feature of the Sri Lankan character. I cannot count the numerous times when a farmer invited our small group for tea and offered us whatever he could give. Very often I left one of these small huts with the feeling of embarrassment for not being able to reciprocate.

Some of the farmers have substantially supported this work and they have freely shared their knowledge with us. I want to mention especially K.M.D.Bandare and his family taught us a lot of his traditional knowledge of plants and agriculture. S.Wegadapala and his family who have generously allowed us to carry out different kinds of experiments in their garden. The Welianga family, who always supported our work with their assistance. The Kodituwakku family, who taught us a lot about indigenous medicine and traditional uses of plants.

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PREFACE

My interest in the *gewatta* system was awakened on my first visit to the island in 1990. During my stay I had a profound discussion with an American scientist, Prof.C.Gans. This conversation influenced me deeply and resulted in the formulation of the essential questions underlying this work.

Both of us participated in an international conference on landscape management in Colombo[1]. During an excursion to small scale farmers near Bandarewela we started a serious discussion. The surrounding scenery was typical for rural areas in the hillcountry of Sri Lanka: the green shimmer of the freshly planted rice filled the valley bottom; stretched out like a carpet along the slopes were the simple houses surrounded by an enormous diversity of trees and enlivened by various kinds of birds. The obvious wilderness and naturalness of these gardens fascinated me. Taken back by the sheer beauty of the landscape I emotionally expressed that these forest-like gardens seemed to manifest a state of harmony between human beings and their natural environment. "Preserve your idealism but don`t think that these people act out of conviction. If you provide them with the means to intensify their cultivation they will willingly cut their trees in order to make more profit." replied Prof.C.Gans, thus pointing out that the perceived harmony might not be the true picture.

This statement turned out to be the question, the shadow of doubt which was to accompany me during my entire research: Is the concept of sustainable agriculture in fact based on a different consciousness towards the environment?
And can this consciousness resist the temptations of a "modern" world?

At the same time this brief discussion created the desire to study the forest gardens, or *gewatta*, in detail and to understand more about the ecological qualities and mechanisms of this age-old system of agriculture.

The presented study is an amended version of my doctoral thesis[2] submitted in May 1995.

For the presentation of this study I decided to write in the plural form **we** in acknowledgement of the research group of the University of Peradeniya and the assistance of Dr. M. Sieghardt (Institute of Forest Ecology, Agricultural University of Vienna), thus pointing out that this work was based on collaboration and mutual interest.

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[1]Ecology and Landscape Management in Sri Lanka. Conflict or Compromise? An International and Interdisciplinary Symposium. 12-26 March 1990; Colombo; Sri Lanka.

[2] The Kandyan Forest Gardens, Gewatta, of Sri Lanka - Their Ecology, Economy and Culture. Doctoral Thesis, Institute of Botany, Agricultural University Vienna, 1995.

PART 1

A Theoretical Introduction

1. The Idea of Nature within the Context of a Tropical Island

1.1. Introduction

> *"Reality" is always unique, it is unknown. But reality always and everywhere affects sensory organs, eyes, ears, brains. These pictures of the world vary with every new generation. We realize that nature, which seems to be unchangeable, continually shows itself in different ways. Nature can be hostile, wild and cruel, it can be inviting, friendly and idyllic, it can be luxuriant and fertile or barren and poor, [...]. Nature alternately appears to be a logical functionalism and an unimaginable mystery, [...].*[1] (Friedell)

These words of Egon Friedell reveal to us the entire complexity and questionability of an attempt to discuss attitudes towards nature of another country and culture. Considering this, we can derive several conclusions which form the conceptual framework of the following chapter.

Landscape and the different structures and `wounds' man has created in the course of time can ultimately not be investigated by analysis alone. At the point where we reach the limits of measurements and data collections we are bound to interpretations. The valuable aspect of an interpretation is the possibility to broaden one`s own views and attitudes towards another understanding of reality. The Western understanding of nature urgently needs this broadening or deepening.

A farmer in Sri Lanka has a completely different idea of a forest than a farmer in Central Europe. Religion, a difference in the historical and cultural background and in the character of the natural environment will result in a conception of the world certainly very different from ours. Out of their conception farmers will make decisions, which will ultimately influence their environment. This process and the visible result, the landscape cultivated by man, will be our field of study.

Our interpretation of this unfamiliar text, the landscape, should open new insights which is the purpose of doing research. The research project presented here plus one and a half years of experience in Sri Lanka can be seen as a source of inspiration for a different idea of nature, for a different way to utilize our resources, and for sustainable agriculture.

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[1] Die "Wirklichkeit" ist immer und überall gleich: nämlich unbekannt. Sie affiziert aber stets andere Sinnesnerven, Netzhäute, Hirnlappen, Trommelfelle. Dieses Bild von der Welt wandelt sich mit jeder Generation. Wir sehen dies daran, daß sogar das scheinbar Unveränderlichste, die Natur, fortwährend andere Gestalten annimmt. Sie ist einmal feindselig, wild und grausam und einmal einladend, intim und idyllisch, einmal exuberant und schwellend und einmal karg und asketisch, [...]. Sie erscheint abwechselnd als die klarste logische Zweckmäßigkeit und als unfaßbares Mysterium, [...]. (Egon Friedell, (1974, 26): Kulturgeschichte der Neuzeit, C.H.Beck, München.

The indigenous Kandyan Forest Gardens, *gewatta*, are an age-old tradition of sustainable land use. Studying these agro-ecosystems we can learn how productivity and diversity have been maintained in an environment easily susceptible to human destruction. Steep slopes, heavy rainfall and the merciless light of the sun can lead to soil erosion and environmental deterioration. In spite of these difficulties farmers have created a liveable and aesthetic surrounding sustaining many of their daily needs. Observing the forest they have instinctively learned to "farm like the forest".

In the following chapter the cultural and social paradigm behind agricultural activities will be investigated briefly. The search for a sustainable human - nature relationship can be deeply inspired by studying traditional farming systems.

Sri Lanka offers many stimuli for this kind of approach. It is a country with a rich, old and traditional culture. The Buddhist religion influences the environmental ethics of people in the rural villages of Sri Lanka[2]. Furthermore the tropical environment of this island, with its immense diversity and complexity, stimulates amazement and thoughts about nature in the observer.

The ecological crisis and the destruction happening there today are urgent calls for ideas of alternative development. Sri Lanka offers us interesting and challenging conditions for the development of new ideas and concepts. As the interpreter of a poem will develop his own thoughts and ideas and may never completely grasp the artists` attitude of mind, likewise we have been inspired by the impressiveness and profundity of Sri Lankas` environment and culture but we should not claim that our interpretations reflect the only possible understanding of reality. This attitude of mind is characterized by a mentality of a scholar and a searcher rather than the mentality of a rigid expert.

In order to limit this vast subject of human - nature relationship we selected some topics interesting for our purpose which will be presented in the following paragraphs. These chapters show a subjective and fragmentary character and leave many parts open for discussion. A literature survey, personal experiences and discussions with farmers, students and monks build the background for the following elaborations. As introduction and to avoid the confusion around the subject "nature", we will use Klas Sandell`s ethnosemantic definition of the term "nature". In his interviews of villagers in Sri Lanka he asked them to characterize the six Sinhala terms corresponding to the English term "nature". Out of this study he formulated a common, abstract core which generally characterizes the way people relate to nature, as "**that which comes of itself**"; in Sinhala: *Swabhawaya, Swabhahavadharmaya, Laksanaya, Lakaye pavatina swabhawaya, Sahaja Gathiya, Wargaya* (SANDELL 1988, 135).

[2] 69,3% of Sri Lanka`s population are Buddhists.

1.2. Sacred Groves - The First Sanctuaries

All over Asia we find the tradition of sacred mountains, forests or groves. In Sri Lanka these concepts arise from different sources. On the one hand the world is vivified by a number of gods, spirits and demons who often dwell in places of natural beauty and people have to pay their respect and veneration to these deities. On the other hand Buddhism brought more abstract and more generally valid concepts for the respect of all living creatures. Non violence, *ahimsa,* and loving kindness, *metta,* towards all living beings, are some examples. Today the tradition of sacred groves presents a vivid bond of both concepts.

> The essential elements of a primitive religion are animism and witchcraft. The world is vivified by an immense number of spirits. These conceptions and rites of the early period of Singhalese history were never anulled when the religion developed further. Gods and demons are realities in the Buddhist cosmology today and the priests never liked to interfere with the individual conceptions of the laypersons (GEIGER 1960, 164).

1.2.1. Mihintale

Mihintale, to use the old name *Missaka,* is a hill near Anuradhapura in the Northern part of Sri Lanka, where the early Aryan colonists from India settled in the fifth century B.C. The following legend tells us about the origin and the founding of Buddhism in about 300 B.C.in Sri Lanka. At the same time the first sacred area came into existence. The King Devanampiyatissa went hunting on the mountain. There he saw an elk-stag browsing in the thicket. Having seen the animal in that situation the king reflected for a while and arrived at the moral judgment:"It is not right to shoot at an unheeding creature." (GEIGER, 1986)

Thereafter the monk Mahinda, who was sent out from India to spread Buddhism, showed himself to the king. Mahinda started to explain to the king the teachings of Buddha. The king, and with him a number of people, converted to Buddhism. "The king formed the delightful royal garden, *Mahamegama,* which was provided, in the utmost perfection, with every requisite, and adorned with fruit and flower-bearing trees of every description" (GEIGER, 1986). Thereafter the king offered this garden to the monk Mahinda. This was the origin of an important tradition which can be observed throughout the history of Sinhalese kingship. Donations of forests, parks and gardens for a temple were counted to be highly meritious acts. Worldly and spiritual powers complemented each other and guaranteed the country`s welfare.

In addition to the creation of the garden *Mahamegama,* Mihintale where the Monk Mahinda and the King Devanampiyatissa met in the forest, was declared a sacred area.

> The converted king declared the Mihintale area a sanctuary for the animals and birds. That royal edict given in the 3rd century B.C. is observed in Sri Lanka up to this day with Mihintale remaining a sanctuary for wild life and flora - probably the first nature reserve in the world (PERERA 1992, 19).

The king was then advised to request that the monk Mahinda's sister should be sent from India so that she could bring with her a branch of the *Bodhi-tree, (Ficus religiosa)*. This tree is the most important symbol for the Buddhists and the planting of a branch of that special tree, where Buddha had sat in meditation before he had gained enlightenment, can be seen as the foundation of Buddhism in Sri Lanka. The *Bodhi-tree* was planted in the newly created garden *Mahamegama* and it became a main centre of ritual. "The chief interest of the kings centred around the bodhi tree; they ruled as bodhirajas deriving their moral right to rule from the bodhi tree" (PERERA 1992, 19).

The laying out of flower gardens and fruit gardens was considered to be meritious work. Many of those gardens were offered to monasteries for religious purposes. (The Pali word for temple, *arama*, means garden or park which clearly expresses the obvious connection between temple and garden.) This tradition, which had its origin with King Devanampiyatissa, can be observed throughout the history of Buddhism in Sri Lanka. Today we can find a number of monasteries situated in natural and beautiful environments. Some of these areas have been transformed into National Parks or World Heritages today and the ancient idea of *ahimsa*, which means not to kill or destroy other forms of life, is converted into modern concepts of conservation. An inscription from the 12 th century A.D. writes about King Nissanka Malla:

> Ordering by beat of drum that no animal should be killed within a radius of seven gau from the city. He gave security for animals. He also provided security to the fish in the 12 great tanks and bestowing on the region's people gold and cloths and whatever other kind of wealth they wished, he commanded them not to catch birds and so gave security to the birds (PERERA 1992,21).

1.2.2. Adams Peak, *Sri Pada*, the Sacred Moutain of Sri Lanka

Adams Peak is another example of an age-old sacred area. The mountain is found in the central province of Sri Lanka. Adams Peak is said to be the dwelling place of the god *Saman*. He protects the island from all evil influence. He has given his name to the butterflies, *Samanalaya*, which come each spring to swarm like yellow clouds about the cliffs of the sacred peak. On top of the mountain we find a rock bearing the mark of a large foot-print, *Sri Pade*, which is believed to be the trace of Buddha's footstep. The Hindus call the mountain Shivan Adipadam, the primordial step of Shiva. For more than a thousand years pilgrims of different confessions have climbed Adams Peak.

> The people of this land count it meritious to go and worship this impression and generally about their New Year which is in March, they, men, women and children go up this vast and high mountain and worship[...]. Out of this mountain arise many fine rivers, which run through the land (KNOX, 1681, 13).

Today the "peak wilderness" is the last part of the island where the tropical rainforest can be observed in the natural succession from a lowland forest (600m elevation), consisting of *Dipterocarpaceae* up to the typical mountain and cloud forest (2000m elevation) dominated by *Calophyllum* - and *Syzygium* - species. The five biggest rivers have their origin at *Sri Pada* and this demonstrates the importance of the mountain, with its thick cover of rainforest for the island's hydrology. The area is under protection today and has the status of a wildlife and nature sanctuary. Nature conservation has never been of utmost importance for the ancient Sinhalese but it was a natural outcome of their traditional practices and resulted in a balance between natural environment and human activities. Religion obviously plays an important role in creating and preserving this balance. Therefore the worship of Adams Peak has a strong symbolic significance for the status of nature in Sri Lanka.

The mountain is also unique because all religions, Buddhism, Hinduism, Islam and Christianity, equally consider it to be sacred. The experience of a pilgrimage to the top of the mountain during nighttime where all people gather to wait for the sunrise is impressive and powerful. When the sun rises the mountain casts its shadow over the highlands still covered with mist, and for a few seconds the clear vision of a dark triangle appears. These few seconds resemble a mystical experience which nourishes our inner being and we suddenly understand why Adams Peak is called a sacred mountain.

- Why did people establish sanctuaries during a time when most of the island was covered with inpenetrable, dense forest inhospitable for man ?

Some answers to this question can be stated as follows: According to Buddhist teachings nature is considered an important source of spiritual development. "The Buddha and his disciples revelled in the silent solitary habitats unencumbered by human activity. Even in the choice of monasteries the presence of undisturbed silence was an important quality they looked for" (DE SILVA 1987, 21). Until today forest monks receive a high veneration.

This approach to nature is quite different from what we can experience in the western world. The contemplative view of nature and the spiritual insight gained by meditation are an important characteristic of the eastern culture. Further on natural habitats were the most important inspiration for the mystical experience of oneness, of the dissolving of duality and the vision of enlightenment. Out of this state of mind places of natural beauty and impressiveness were selected for monasteries and sacred areas. How many of those sacred places are still in existence today was not accurately observed. But

each monastery has its boundaries within which strict regulations regarding the natural environment are observed by the monks as well as laymen. The spiritual power of many of those places can still be experienced today and a susceptible visitor will undergo feelings of tranquility and serenity.

- What was the reason for the protection of wild animals which were a constant threat to the people ?

To live in peace and harmony with wild animals was important for the development of spiritual qualities like fearlessness, kindness and mindfulness towards all living beings. A special feature of hermitages was that these monks lived among wild animals like bears, leopards, wild buffaloes, wild boar, or elephants. This can be illustrated with the following legend of the monk Pannananda: "Sometimes when Pannananda went out in the early mornings to pace back and forth on his meditation path, a leopard would be stretched out dozing in the sand. Pannananda would then shoo the leopard away and calmly begin his meditation." (CARRITHERS 1983,85).

The protection of wild animals was not only practised in the past but can still be observed today. Lynn White, Professor of History at the University of California, describes the attitude of village people towards wild and even dangerous animals as follows[3]:

> British colonial officers were making new roads in the jungles so that the crop of the great tea plantations could go to market more efficiently. In the red cuts slashed through the dark green vegetation I saw cones of earth left standing and asked what they were for. "Those are snakes´ nests," I was told. They were spared not because the workmen were afraid of snakes - everybody in Ceylon learns to live with snakes - but because of a feeling by the workers that the snake had a right to its house so long as it wanted to stay there.[...] Many of the officials seemed to be Scots, and it occured to me that if the men with the shovels in their hands likewise had been Presbyterians the snakes would have fared less well.

Everett records in a paper on homegardens in Sri Lanka[4]: "The villagers are predominantly Sinhalese Buddhists who in everyday action avoid killing. The socialization is strong. I have never seen a villager kill a bird or mammal, and people are likely to let a poisonous snake go too".

These observations indicate that the environmental ethics of village people contributes to the rich wildlife which can be observed in the rural areas of Sri Lanka.

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[3] Lynn WHITE, Jr. Continuing the Conversation, In BARBOUR I.G.(at)1973: Western Man and Environmental Ethics. Attitudes.toward Nature and Technology. Reading, Massachusetts

[4] Homegardens in Sri Lanka: Patterns and Changes in the Highland Landscape. Paper prepared for the Conference on Integrated Land-Use and Biodiversity in China, October 1991. Department of Forestry and Resource Management, University of California, Berkley.

1.3. The Position of Forests throughout the History of Sri Lanka

Nature as "*that which comes of itself*" is found in the wild and impressive appearance of the tropical rainforest, which covered nearly the entire central highlands of Sri Lanka. The place of value forests took up in the history of the island is an important indication for the inhabitants` attitudes towards nature.

Today we must realize the terrifying fact that the island, which was once nearly completely covered with rainforest, is denuded and dismantled of its beautiful cover. In 1881 the estimate of forest area was 84 % of the land for the entire country and in 1900 70%. In 1961 the total area of forest had decreased to 44 % and the most recent figures show that the forest area is still diminishing today. In 1983 there was 15,9 % natural forest left for the whole island (BALDWIN 1991, 197). These figures illustrate the over-exploitation practised in the last few decades. If we look back in Sri Lanka´s history we learn that there has always been a traditional practice of forest conservation, yet this had been completely neglected during colonial times and after independence.

The first Arian settlers must have cleared large areas of forest for agriculture in the northern part of Sri Lanka. The colonisation of this part of the island started along the course of rivers and was scattered in the lowland plains. From 200 B.C. to 300 A.D. these settlement expanded into higher elevations. The next phase of settlement covered greater parts of the lowlands in the wet and dry Zones, and the lower valleys of the highlands were also occupied by the end of this phase. During a period of roughly 1500 years (4th century B.C. to the 12th century A.D.) vast areas of the dry zone were cleared of forest and cultivated.

The hydraulic civilisation (named after their exceptional irrigation works) established in the northern part of the island reached its zenith with the ancient kingdoms of Anuradhapura and Polonnaruva. To a great extent these kingdoms, based on a highly developed agriculture, flourished because a plentiful supply of water was assured from the complex system of irrigation works which fed the arid plains. Those supplies of water came, for the most part, from the well-wooded hill country of the south central region with its thick cover of primeval rain forests, which trapped rain water with its soil and, preserving it in subterranian channels, released it in perennial supplies to streams and head waters of the big rivers (KARUNARATNA, 1974).

With the decline of the ancient kingdoms in the 12th century the settlements shifted to the southwest and later on to the Central Province. For the first time great parts of the wet zone were colonized and the forest cover was reduced to make way for settlements and agriculture. The system of agriculture established there followed the traditional pattern of the earlier settlements. The village (*gama*) consisted of paddy fields, gardens of miscellaneous fruit trees (*gewatta*) and chena (*hena*), that is jungle land cleared, burned and cultivated periodically. The "wet" method of rice cultivation mainly practiced in the highlands depended on rainfall and small streams of water being

diverted to the fields. The hilltops, still covered with primeval forests supported the water supply.

- How was the protection of forests practised by those ancient civilisations?

Protection of forest was practised with the establishment of sacred areas. As described in the earlier chapter, the king donated parts of his land and forests for religious purposes to the monk order, *sangha*. "It can be safely assumed that the royal parks and forests offered to the Buddha and the *Sangha* were protected forests where beasts, birds, fish, insects and reptiles could live and be secure from man`s destructive powers" (KARUNARATNA 1986, 30). These sacred forests must have been one of the main means of conservation.

Another tradition practised by the Kandyan kings was the establishment of forbidden forests, *Tahansi Kelä*. They came under the strict protection of the king and it was not allowed to cut down the forest for chena cultivation, and hunting and logging of timber were interdicted as well. The king employed *Käle Korales* who can be seen as forest officers. It was their duty to protect the forbidden forests, *Tahansi Kelä*, which belonged to the king (KARUNARATNA 1986).

The king was the lord of the land, *bhupati*, and the forest also belonged to him. These forbidden forests reach back to ancient regulations like the comprehensive Indian treatise on law - the *Arthasastra of Kautilya* (4th century B.C.): "When a person entraps, kills or molests deer, bison, birds and fish which live in the forest under protection, he shall be punished with the highest amercement"[5]

Apart from religious motives forests were also preserved as an important source of water. The vital importance of water for an agricultural society cannot be underestimated. From the 4th century B.C. up to the 12th century the so-called "hydraulic civilisation" was strongly dependent on the water supply. The central region still covered with primeval forests was the origin of most of the big streams supplying the rest of the island. What we call watershed management today was already practised by the Sinhalese kings. The ancient tradition that kingship was connected to rainfall can be observed in literature and religious texts. A righteous and religious ruler will guarantee the country`s wealth and the rain will come at the right time. An important Buddhist stanza shows the obvious connection between rain, agriculture and kingship:

May the rains fall in due season, may there be a rich harvest;
May the world prosper, may the ruler be righteous[6]

Apart from the necessity for forest preservation owing to its direct bearing upon irrigation the king needed forests for his large supply of timber for public buildings.

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[5] John M. Seneviratne (1920): Kindness to Birds and Beasts in Ancient India and Ceylon", Ceylon Antiquary and Literary Register, Vol. VI, Part 1 In: KARUNARATNE (1986).

[6] *"devo vassatu kalene, sassa sampatti hetu ca*
pîto bhavatu loko ca, râjâ bhavatu dhammiko

Therefore the kings maintained a regular Forest Department and appointed forest guards. All these special arrangements show that in the Singhalese kingdom there was a royal monopoly on timber, as there was no private ownership of forests.

In addition the forests were the areas where wild elephants bred. Elephants were important for the king not only for the work they undertook but also for demonstrations of power and wealth. Traditionally, trained elephants were exported to India and brought additional income. During the time of war between the colonial powers and the Kandyan kingdom the forest offered the best opportunity for defence. The guerilla war conducted by the Kandyans was successful because of the impenetrable forests surrounding the city of Kandy. Last of all and the most difficult to proove, there must have been a certain feeling of respect and awe, which induced people to preserve forests.

> Down through the ages the atmosphere of a primeval forest has evoked a certain feeling in man, a feeling bordering on a mystic experience concerning the mystery of nature. Poets have given utterance to this feeling in words such as "Even the gods dwelt in the Woods" and "The groves were God`s first temples (KARUNARATNE, 1986, 29).

In the course of many generations traditional knowledge evolved about how to use the diversity of plant species found in the forests. Medicine, spices, fruits, plants for building material and other purposes, were collected and the forest formed an integral part of the village agro-ecosystem.

The result of all these regulations and practices was ecologically valid and maintained a sustainable system of land use for many centuries. A sufficient supply of water was guaranteed, elephants and other wild animals still found a place to live, and the enormous biodiversity of the tropical rain forests could be preserved.

For people living in these regions, the tropical vegetation, with its diversity and fullness, has probably mediated a different consciousness of man`s position in this world. The tropical rainforest represents a habitat which is rather hostile for human intruders. Insects, leeches, the damp humidity and the impenetrable dense vegetation do not offer comfortable circumstances for human settlement. The achievement of the Sinhalese culture in having created a system of landuse balancing human pretensions with the natural environment, cannot be valued highly enough.

This somehow balanced co-existance between human beings and nature was disturbed by secularisation and the loss of traditional values, by major changes in agriculture, as well as by modernisation and industrialisation due to western influence. The disastrous process of destruction which characterizes the late 19th and 20th century will be briefly documented with the following example.

1.3.1. Udawattekelä, an Example of a Forbidden Forest

Udawattekelä is situated behind the *Dalada Maligawa*, the "Temple of the tooth" in Kandy. The forest was strictly guarded by the Kandyan kings. It was used for defence because the king could easily escape through the dense vegetation. No one was allowed to enter the forest except the king and the royal family as well as monks residing there in a hermitage. Elephants, leopards and deer were found in the jungle, and streams which were important for the irrigation of paddy fields had their origin inside the forest. A temple was dedicated to the meditating monks inside Udawattekelä and the natural habitat was preserved without major impacts for centuries.

All these facts were ignored by British administrators after they secured possession of the Kandyan province. The forest was partly cleared for the purpose of erecting military barracks, partly for the Governor's residence, for roadways and coffee plantations. Finally only a small patch of natural forest remained, still adding scenic beauty to Kandy town. At the end of the 19th century the British themselves realized the need for forest conservation. Udawattekelä then became the first forest to be proclaimed a Forest Reserve by the British. This proclamation took several years and the management of the forest was still not organized. "On July 12th 1938 Udawattekelä was proclaimed a sanctuary. This was almost eighty years after it was declared a reserved forest in 1856" (KARUNARATNA 1986, 44).

These facts clearly show how slowly the administrative procedure of forest protection was executed. Today the forest has been replanted and is developing a more natural appearence, though the original vegetation has been lost. Udawattekelä symptomatically illustrates what happened to the entire island, only that in most of the other cases no effort was made for protection. Plantation enterprise, unregulated chena cultivation and thoughtless exploitation are resulting in the loss of forests up to the present day. The lesson we can learn from old traditions and wisdom is clearly expressed by A.C.Clarke[7]:

> A world that contained only human beings would not be worth living in, nor would it be habitable very long. This is a lesson that our urban-centred, technologically oriented culture is painfully relearning, though our ancestors knew it well enough. A holy man once told the ruler of Ceylon: "Oh, great King, the birds of the air and the beasts have as equal a right to live and move about in any part of this land as thou. The land belongs to the people and all living beings, thou art only the guardian of it." For as King Devanampiyatissa was told three centuries before the birth of Christ, we are its guardians - not its owners.

[7] CLARK, A.C. 1983. Sri Lanka's Wildlife Heritage. A Personal Perspective. National Geographic 164/2

1.4. Living with the Forest - The *Gewatta* System

As a conclusion of the previous chapters we must raise the question whether a non dominant and rather contemplative view of nature will lead to agricultural systems less exploitative and aggressive than ours.

The forest like gardens, *gewatta*, surrounding the villagers` homes, resemble a special kind of adaptation to the ecological conditions of the wet zone of Sri Lanka. Originally the system of homegarden evolved in dry zone villages and was adopted and modified in the wet zone. There the climate favours a large variety of tropical fruits and the diversity of trees formes a forest-like ecosystem. These ecological adaptations will be referred to at length in the practical part of this study; here we will discuss the cultural and religious background.

In our opinion the *gewatta* symbolizes the attitude of "letting grow". It can be called a kind of agriculture where the farmer seems to go with nature rather than to work against it. The farmers of Sri Lanka have observed the forest, living in and with it for centuries. From the structure, diversity and dynamics of a natural forest they have instinctively copied the principles of productivity and sustainability. The *gewatta* has evolved imitating the natural forests, only differing in that the combination of species varies due to the selection according to human requirements.

The merciless light of the tropical sun has evoked a preference for cool and shady places. The so called "*vadulla*", shady and forest-like vegetation, is much more desirable for the average Sri Lankan than a grass lawn. Accordingly they have created a livable environment by planting trees.

Apart from that it is a striking fact that most of the gardens are not planted and designed in a systematic manner. The farmer`s idea and his concept of a garden is, as we find with most of our agricultural systems, not the main importance. Therefore the *gewatta* resembles a state of wilderness rather than of horticulture. The farmer rarely imposes his ideas: here I want a coconut tree to grow and there should be a coffee bush - but on the contrary "that what is coming out of itself" is used and slightly directed for the farmer`s utilisation.

A high percentage of species found in a traditional *gewatta* have been germinated by wild propagation. Some trees are never planted, like the kitul palm (*Caryota urens*), a common tree in traditional gardens, which is propagated by a wild animal, the civet cat (*Poradoxurus hermaphroditus*).

Instead of eliminating these "wild guests" people have gratefully accepted them and have learned to use them for their own benefit. The kitul palm, for example, gives a sweet palm sugar which was the only means of sweetening dishes in earlier days. Likewise many other wild plants are used as medicines, food, spices, beverages, building material, shelter, clothing and for many other purposes.

The general attitude can be characterized with an often heard saying: "every plant is a herb" which means that every plant has some medicinal value. The *gewatta* resembles a long tradition of learning from the gifts of nature. For instance the high number of medicinal plants found in an average garden can prove this fact. Many plants which have already been declared as weeds and enemies of the western one-cash-crop production system, are used by the villagers in Sri Lanka to enrich their meals as salads or leaf vegetables. These plants do not only increase the nutritional value of food but also preserve biodiversity. Further more ornamental plants grown around the house are mainly used for religious purposes and enrich the villagers` lives with aspects of beauty.

The tolerant and adaptable way of agriculture which accepts "what comes from itself" ultimately results in diversity and sustainability. The coexistance of man, plants and animals can be harmonious. To tolerate "wilderness", to accept the sprouting and growing of nature, is an essential part of these man-made ecosystems.

In spite of the long period of colonisation the landscape in Sri Lanka still reflects these attitudes to a certain extent. Lynn White reveals a similar perception in the following paragraph:

> Only later, after I had read Max Weber, did I begin to wonder whether autonomous Buddhist Singhalese would have ever laid out those tea plantations and consequently build those roads. It was not that they lacked energy or imagination: their temples and ceremonial dancing surpassed Edinburgh`s kilted dancers. Different cultures expend their capital, energy and imagination in very different proportions upon different sorts of creativity (WHITE 1973, 55).

In Western countries we have forgotten this kind of tolerance and our cultivated areas resemble a permanent fight against "wilderness", against weeds, against "what comes of itself". Ultimately this attitude leads to destruction because the basic laws of nature are not accepted. Agriculture should relearn to work with the qualities and laws inherent in nature instead of fighting against them.

1.5. Rituals, Myths and Beliefs Connected with Nature

The villagers` life and customs resemble a small world within the larger context of the Sinhalese culture. The diversity of myths and beliefs tell us about the villagers` conception of the world. Rites are the visible forms and the key for understanding another culture. The question we have to ask at the beginning of this chapter is whether the traditional customs are still alive in the sense that the villagers not only observe them automatically but that they are inwardly directed by them. For an outsider it is very difficult to evaluate the genuineness of tradition. Sri Lanka finds itself, there is no doubt, in a process of transition, of modernisation, and the values, dreams and hopes of the younger generation might be completely different from those of their parents. But

nevertheless the core of this old buddhist culture still exists and the conservative attitudes of most of the Sinhalese tend to preserve it further.

The Sinhalese villagers' way of preserving the old, while adapting the new, was described by Emerson Tennent in the mid-nineteenth century. He observed that the Sinhalese were like a "yielding fluid which adapts its shape to that of the vessel into which it may happened to be poured, without any change in its quality or any modification of its character" (RYAN 1958, 193). Therefore it is quite difficult for an outstanding scholar and observer to articulate the character of Sinhalese society and culture.

Many ceremonies belonging to traditional agricultural practices were connected to a world full of supernatural powers. The following chapter will give a brief introduction to these traditional customs found in Sinhalese villages. These customs and rites reveal to us the position of nature and the concepts involved. B.Ryan in his book "Sinhalese Village" describes the village cosmology in the following way:

> Very roughly we distinguish six types of supernatural powers active in the life of the villager. Although these powers are not hierarchically graded, Buddha stands above all others, and towards him there is a unique reverence and worship. Surrounding the Buddha is the largely Hindu pantheon, especially Vishnu, Kataragama and Saman, a distinct Singhalese deity. In a third category are the planet gods influencing every phase of the individual's life. Utterly apart from planet gods, but affiliated with the pantheon of devas are the yakas or demons and with them a multitude of wood spirits and ghosts (RYAN 1958, 106).

1.5.1. Devas

Devas live everywhere in the visible world. They are called *bhumaattha*, earth-deities, in contrast with the heavenly gods *akasattha*. They can live in trees, *rukkha-devata*, or mountains. "There are said to be 33 million devas. These include gods derived from Hinduism, indigenous Sinhalese gods, and vague entities, neither good nor bad in relation to man, but for whom some regard should be shown" (RYAN 1958, 109).

As is still believed by the modern Sinhalese, a man owes his good fortune, luck and success, health and life to the devatas, the tutelary deities, and their protection. At almost every stage of agricultural work the farmer has to observe rituals and ceremonies to satisfy the local devas. Harvesting and threshing are especially auspicious acts which are connected with a multitude of customs. Before the paddy is ripe to be cut an auspicious day is fixed by the astrologer. A young child is selected to cut the first bundle, his face looking in the direction of the sun. This first bundle will be fixed on the roof and offered to the birds to feed on it. Thereafter the harvest begins, men and women working together and cutting the bundles of rice with a special knife.

Before threshing the rice a mandala is drawn with chalk. A shell, the symbol of fertility and a sickle are placed in the middle of the mandala before the buffaloes start their work of threshing the rice. A belief exists that the seeds on the threshing ground are released by the guardians of the earth. *Goyam Male*, harvest hymns still performed, also indicate beliefs in supernatural powers:

Grace have I received from the Sun God and Moon God;
Grace have I received from the Goddess of the Earth;
Grace have I received from the Deities of the Universe;
Blessed with divine grace the harvest I begin to reap. (DE SILVA, 1974,64)

Throughout the work of threshing and measuring the rice, the farmers maintain a sacred atmosphere; rice has been the foundation of their life for more than two thousand years and the "respect" for this crop is still visible. Every farmer treats seed rice with respect and care and it is quite usual to remove shoes before walking over a paddy field. Before cooking the first freshly harvested rice vows and offerings have to be observed. People give the first rice offering to Buddha, which is carried to the temple, *Alut bath dane*. A study carried out by Klas Sandell in 1988 mentions several other rituals still practised by the villagers:

> The *panam bandeema*, tying coins to get enough water and to protect the harvest, the *mutti neveema*, turning pots upside down on poles for the God of the tank building kingdom, the *kiri itiraweema* after a good harvest when coconut milk is boiled until it overflows. Every third year the great alms-giving, *mahadane*, is performed for the protection and progress of the village. These rituals are carried out to get the protection of the local devas and, not least, to get enough rain" (SANDELL 1988, 147).

The farmer is almost entirely dependent on natural rainfall to irrigate his fields, and the unknown forces that bring harm should be guarded against by magic charms. Therefore many rituals are connected with rainfall. Local devas are worshipped, and vows and offerings should put them in a favourable mood and guarantee their protection. (WIJESEKERA, 1965)

It is important to mention that these concepts of a world full of gods, demons and devas have resulted in a different feeling towards life and further more in different attitudes towards humans` position and function in this world. Also the unifying role of rituals for the villagers should not be underestimated. Cooking and celebrating together and performing the ceremonies in a good way will certainly result in a strong feeling towards the community and environment you are living in. The social structure and the feeling of unity within a village will benefit from these rituals.

> Not surprisingly young people seemed to have less faith in the rituals than those who were old. They also expressed the view that it is better to perform rituals because one never knows what will happen otherwise. This illustrates

a situation in which the traditional value system is becoming less significant but still has a good hold on the people (SANDELL 1988, 149).

1.5.2 .Demons

Demons are not so much connected with agricultural practices, as they are believed to cause certain diseases. In the work of B.Ryan "only six out of a hundred men interviewed expressed outright disbelief in demon reality" (RYAN 1958, 111). Today the situation presents itself differently and exorcists practice their art only in traditional villages of remote areas. Mental diseases are especially treated with *bali* or *thovil* ceremonies. These exorcist dances are impressive ceremonies where beautifully carved masks are used to frighten the demons; drums and dancing go on throughout the night and the entire village participates. The exorcist is an important personality in the village; he is also invited to perform various ceremonies concerning the birth and the protection of a child.

1.5.3. Planet Gods

The most pervasive and encompassing supernatural system is that of the planetary gods. There are said to be nine planet gods who have a different influence on an individual`s life. Rahu, for example, is a god to whom the eclipse of the sun and the moon are ascribed. Every child has a horoscope cast at birth. Usually the Buddhist monk is educated to draw horoscopes which are still written on Ola-leaves. These leaves of the Talipot palm (*Corypha umbraculifera*) were used for religious texts. Today the skill of writing on these leaves would be lost if it were not for casting the horoscope. The horoscope is carefully guarded and only taken to an expert astrologer for special occasions like marriage. "According to common belief it was of greatest importance to begin each undertaking, might it be a trivial one or one of great consequence, at a lucky hour" (GEIGER 1960, 175). The time when a child will have his hair cut for the first time, his first meal of rice, his first lesson and other important happenings must always be according to what the astrologer calculated to be the auspicious hour which is true even today.

It is a common belief that through an understanding of the planetary gods and their influences, all events in life can be forecast and wisely acted upon. The calendar established in Sri Lanka followed the changes of the moon. With expanding trade and external relationship the original calendar was changed to the Western model. The full moon day, in Sinhala called *poja*, is still a public holiday. During a full moon day activities like fishing, cutting firewood, any form of hunting and killing, burning chenas, clearing land and other agricultural activities will be avoided.

1.5.4. Worship of Trees

The importance of nature in Sinhala literature is striking, there are many examples of poems written about trees, birds, beasts or other beings. The expression of feelings, the romance and innocence of poems, songs or folk stories is always combined with allegories from nature. There is hardly a love song which does not contain a description of flowers, trees or natural sceneries. The traditional riddles and stories found in villages would be a vast field of study on this topic. The high status of nature in Sinhala literature highlights the obvious closeness of feelings to the arts and nature. An important writer, Martin Wickramasinghe, describes with great impressiveness the close interaction of village and nature.

> *A tree is a wonderful living organism which gives shelter, food, warmth and protection to all living beings. It even gives shade to those who wield an axe to cut it* (Gautama the Buddha, inscription).

The tradition of tree worship is still very vividly alive in the traditional villages of Sri Lanka. Apart from the many uses trees provide, the villagers recognize them as living and divine personalities. "Singhalese workmen who have to make a road through the wilderness hesitate and even refuse to fell such a big and old tree when they meet it on their way" (GEIGER 1960, 177). Large trees are called *vanaspati* in Pali language, meaning the "lord of the forest". These trees are assumed to have some powers and it is meritious to worship them.

Among the trees the bodhi tree, *Ficus religiosa*, is the most venerated. As mentioned earlier a branch of the holy tree of Bodh-Gaya, where Buddha attained the enlightenment, was brought to Sri Lanka by the nun Sanghamitta. When the tree was planted eight shoots sprang from it in a miraculous manner. Since then the tree has become widespread on the island. It is found in almost every Buddhist temple. Wherever it grows it commands a deep-rooted veneration from the Buddhist. In the opinion of some it is the principal object of worship at the present day (RANASINGHE 1971). Like its pliant roots, which find sustenance on the face of a bare rock and cleave their way through the stoutest fabric, the influence of what it represents has penetrated into the innermost being of the people till the tree itself has become almost human.

It is important to state that originally the tree was not supposed to be worshipped for itself or the *devas* living in it, but mainly because it was a symbol for the enlightenment which Buddha had attained meditating in the shade of a bodhi tree. Today`s belief is often that the tree will fulfill one`s wishes and hopes, and the rituals and *pujas* (offerings) carried out are sometimes not in remembrance of the enlightenment. But in spite of these more materialistic attitudes the *Bodhi-puja* is an impressive and moving ritual. Particularly the tree in Anuradhapura, which is more than thousand years old, is worshipped by a huge number of pilgrims who come there at full moon. They spend the night lighting oil lamps, offering water, sometimes milk, flowers and incense sticks. The *puja* is accompanied by the recitation of *Pali stanzas*,

religious texts, and meditation. The impression a visitor gets is of peacefulness and calmness.

> It should give any human being a feeling of humbleness and peace, spending a night meditating under a tree. The attentive and susceptible visitor will hear the bats who come and feed on the tree during the night; the soft whispering of the leaves and the movements of the stars will complete this experience.
>
> Tending the *bodhi* tree constitutes a part of the duty of every *bhikkhu* (Buddhist monk). He is expected to water it and cleanse its courtyard. For a monk, seeing a *bodhi* tree is a matter to be rejoiced at. It is further admonished that a monk who enters the courtyard of a *bodhi* tree should revere it by his respectful behaviour as if he were in the presence of the Buddha (RANASINGHE 1971, 28).

The most venerated tree in Anuradhapura is attended by a special botanist who has to visit the tree regularly as diseases or other problems would be deemed a disaster for the whole country. Beside the *bodhi* tree other trees are regarded as sacred because different Buddhas attained enlightenment under these trees. The naa tree, *Mesua ferrea*, is the tree of the Buddha of the future, *Maitreya*; it is also regarded as the national tree of Sri Lanka. *Couroupita guianensis*, and other species like *Ficus benghalensis, Ficus mysorensis*, bamboo, *Bambusa vulgaris*, or mango, *Mangifera indica*, are treated with special veneration. There are some differences between Buddhists and Hindus regarding their sacred trees but the origin of tree worship lies in the Vedic period where mystic and divine qualities were attributed to some specific trees.

Apart from the veneration of trees out of religious motives they play an important part in the traditional *aryuvedic* medicine. This system of medicine cannot be referred to at length in this context, however, it originated in India more than 2000 years ago. Trees and herbal medicines are prepared in complicated mixtures in which leaves, bark, roots or other different parts of a tree are used. The *aryuvedic* doctor is supposed to worship the tree before collecting the medicine as only this veneration will release the healing power of the plant.

Out of 75 tree species considered to be of medicinal value five of the more important plants that are also worshipped for various religious reasons will be briefly described.

The neem tree or nim (*Azadiracta indica*, Sinh.: Kohomba or Margosa) is one of the most important medicinal trees. " If sweet are the uses of adversity, sweet are the benefits occurring from the nim tree whose leaves are extremely bitter" (Majupuria, 1988). Nearly 40 different uses are documented. The tree is worshipped especially by Hindus and is often planted in front of their houses. Today it has got a new importance because the seeds can be used as pesticide.

The bael fruit tree (*Aegle marmelos*, Sinh.: Beli) belongs to the Hindu goddess Lakhsmi; to plant the tree in front of the house means fertility. The fruits have a high medicinal value for stomach problems. A refreshing drink can be prepared from the ripe fruits.

The wood apple tree (*Feroinia limonia*, Sinh.: Divul). "In India we find the tradition of offering to this tree in the name of the serpent king (Shesha)" (Majupuria, 1988,). The fruit of this tree is an aromatic stimulant. The fruit is prepared into a tasty jam and can be eaten with sugar and honey. The story goes that wild elephants who come to eat the fallen fruits get drunk by feeding on the fermenting fruits. Thereafter they dance and enjoy themselves during the night.

The champ tree (*Michelia champaca*, Sinh.: Hapu) is mentioned in folk tales. For example one minister's daughter changed into a Champ tree with flowers of gold. The tree is thought to be a personification of Lakshmi and it is believed to increase the wealth of the family (MAJUPURIA 1988). The leaves, stems, fruit and seed contain an alkaloid. The flowers yield champaka oil which is used as a perfume.

The sandalwood tree (*Santalum album*, Sinh.: Sudu-handun) is described as always being surrounded by snakes owing to its fragrance and cooling effects. The oil of this tree is used against skin diseases and in perfumery. The powdered, scented bark is essential in many ceremonies. The heart wood is used to cure fever (JAYAWEERA 1982).

The honey tree (*Madhuca longifolia*, Sinh.: Mi gas) was very important in the dry zone. The oil of the seeds was used for cooking and lighting lamps and as mentioned later the tree was often planted near paddy fields. The medicinal value of the bark and seeds is still commonly known and the tree gets special veneration because of its traditional value. It is a fascinating and often reviewed fact that myths and beliefs contain a core of truth. Religious beliefs, superstitions and medicine flow into each other without a strict borderline.

1.5.5. Flower Offerings

One of the most common ways of gaining merit is that of personal flower offerings and oil lamp lightings at the temple, *vihare* on full moon days. The following stanza is repeated though few of the villagers might intellectually understand the significance of the words:

> *With these flowers I pay my respect to the Buddha and gaining merits I will work on the realisation of nirvana. These beautiful flowers shall fade and wither, in the same manner my body too will some day be destroyed.*[8]

[8] *"pujemi buddham kusumenanena, punnenametena labhami mokkham, puppham milayati yatahi dhamme, kayo tathayati vinasa bhavam."*

Flowers symbolize *anicca*, impermanence. Tropical vegetation has cycles very different from those of our vegetation. It seems that the process and the cycles of life are more obvious to the observer there. Life and death are closer. Whenever we see flowers and blossoms in the same moment there is also rotting and death. The trees in the rainforest never shed all their leaves at once, but lose them continuously. This process of permanent change is used in many Buddhist parables to make one understand *anicca*.

The lotus, (*Nelumbo nucifera*, Sinh.: Nelun) is regarded by both the Hindus and the Buddhists as being the most sacred flower. The lotus flower can be found in front of every big temple where children or mostly women sell the flower buds. The lotus is also part of a legend of Buddha explaining the evolution of mankind: the root of the lotus is stuck in deep mud; through the slimy water the plant tries to reach the clearer surface stretching its blossom towards the sunlight. In the same way mankind also struggles to free itself from deep constrictions towards a clear and free state of being.

Besides the lotus many other flowers are used for worshipping the Buddha. White blossoms are especially preferred, such as jasmine (*Jasminum sp),* Watu-sudhu (*Ervatamia divaricata*), or the flowers of the temple tree (*Plumeria sp.* Sinh.: Araliya) which can be seen wherever Buddhists worship. Some of these plants, like the lotus or jasmine, have a medicinal value as well and they are used in the indigenous system of aryuvedic medicine.

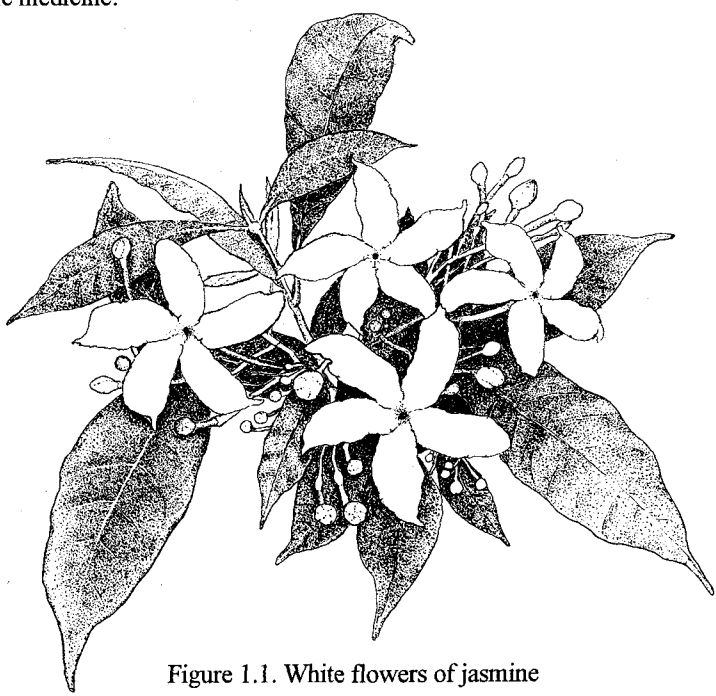


Figure 1.1. White flowers of jasmine

1.6. Conclusion

In conclusion it can be assumed that the traditional way of life in a village is still characterized by a number of beliefs and rituals. The logic and unpassionate core of the Buddhist doctrine is supplemented by a magical-supernatural system that forms the basis of villagers` attitudes towards nature today. Devas, demons and planet gods are part of human life. They have to be satisfied with different offerings and vows in order to avoid diseases and disastrous events. Beside the supernatural world the natural world is also assumed to be vivified by spirits and deities. These rituals are by no means savage and meaningless but rather they involve a careful and conscious use of natural resources. Human beings, nature and gods are connected in one complex system of mutuality.

The educated and informed new generation might smile about the "old stories" but in the rural villages of Sri Lanka people still feel that they "are part of a larger system, a cosmology, uniting man, God and nature and prescribing the proper relationship between them". (SANDELL 1988, 136)

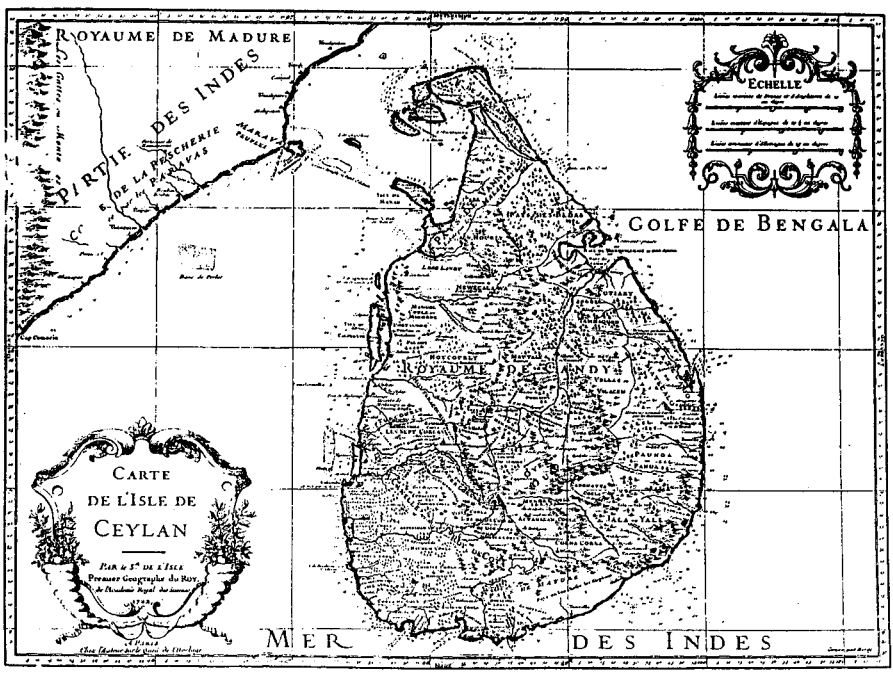
In conclusion of this chapter an attempt should be made to alter our present way of thinking, for otherwise this journey back into ancient customs and practices would have been useless. The concepts of the world as they are found in rural villages in Sri Lanka express a decent respect for all living creatures. If we ask a peasant: "Do people have ethical obligations towards rocks?" he probably would reply "Yes" and this reply would reflect his ideas about the nature of reality. But to almost all Western societies the question makes no sense at all.

The last century in Western countries is marked by an implicit faith in progress and growth. This faith was persuasive and convincing enough to spread from the West all over the world. Likewise in Sri Lanka the new gods of technology and science are replacing the ancient beliefs. But the Western world has become doubtful about it´s success. Now that the villager in Sri Lanka dreams of a car and a refrigerator, we are often frustrated by our material achievements and seek a meaningful life. From our point of view we face the major problem that it is impossible, bearing in mind the capacity of the earth, for everyone to live according to present Western standards concerning energy consumption, waste production and deterioration of natural resources.

Therefore it seems that no solution is possible other than a step towards a new cultural process: self-restriction and renunciation according to ecological, ethical and spiritual insights in Western countries. Only then might the ongoing conflict between North and South, rich and poor, or "developed" and "undeveloped" countries find a new basis for communication. This communication could become the most fascinating and challenging possibility to deepen our understanding of reality. The urgent call for more wisdom and kindness towards our environment should not be ignored.

PART 2

A Brief Historical Investigation



2.1. Precolonial Agriculture

2.1.1. Introduction

> *The predilection for rural life of the Sinhalese and the extraordinary value they attach to agriculture, are admirable. They are characteristic of their whole culture which was always closely and virtually connected with and, dependent upon, the soil, from which it had sprung. The agriculturalists were the nobility of Ceylon and the Sinhalese were ever conscious of the fact that agriculture is the basis of the economical welfare of the country* (GEIGER 1960, 85).

The following chapter is an attempt to describe the main features of the traditional subsistence agriculture as it has been practiced for nearly 2000 years in Sri Lanka. The fact that farmers have maintained an ecologically rich and diverse landscape for that long cannot be ignored. Therefore it is worth while to look at traditional land use systems, though they might not be appropriate for today's situation. Traditional land use in the strict sense can only be understood as the pre-colonial system of agriculture. Furthermore we must distinguish between dry zone and wet zone agriculture.

The village homegarden, *gewatta*, has been an integral part of the agriculture of traditional villages. Only if we take the entire historical and ecological development of the island into consideration can we understand the function of the *gewatta* system in the agricultural context of Sri Lanka today. A brief historical investigation is therefore necessary for an integrated approach and understanding of these forest-like gardens.

> Man has been recorded in Sri Lanka since 125,000 B.P. starting with small-flake industries and evolving to microlithic stone (Mesolithic) industries by about 30,000 B.P. [...] Thus the landscape of today represents the upper part of a landmass that was existant in the Holocene. Man's impact on these landscapes can be traced fairly clearly from the Middle Holocene onwards, due to the existence of recorded history. However, it must be noted that, while empirical evidence such as for Giant Tanks near Mannar suggests sophisticated agriculture long before the advent of the Sinhalese, the oldest historical chronicle of the island, the Mahavamsa, places the tie of agricultural development at about 543 B.C. (SENANAYAKE, 1993, 211).

According to the *Mahavamsa* agricultural activities originated in the dry zone when the Indo-Aryan Sinhalese immigrated from North India. They must have brought rice cultivation and irrigation techniques with them. Irregular rainfall and dry conditions created difficulties in establishing rice cultivation. Therefore very early in history the skills of irrigation were developed which formed the basis for agriculture. The number of tanks constructed in this area are said to exceed 10.000 and the surplus production supported cities, schools, libraries and a large monastic population (SENANAYAKE 1993).

2.1.2. Important Components of Precolonial Agriculture

All village agro-ecocomplexes had characteristics in common, so that they were often almost identical. Each village ecocomplex had four major components, namely paddy cultivation, shifting cultivation, homegardening, the village forest, fishing and to some extent animal husbandry.

Irrigation

As mentioned earlier the advanced irrigation works formed the basis for any agricultural activity. The main crop produced in Sri Lanka during that time was rice. Two different systems of irrigation were used for paddy cultivation. One form of cultivation was based on tank irrigation. Accumulated rainfall was collected in artificially built tanks, *wewa*. After the rainy season the water was distributed through channels to the fields as required. The small tanks were arranged into a cascading sequence with micro-catchments in between. Drainage from the paddy fields in the upper part of the cascade flowed into a downstream tank for reuse in the paddy field below. "The system fully expressed the well known dictum by the King Parakramabahu (A.D. 1153) that not a single drop of water received from the rain should be allowed to escape into the sea without being utilized for human benefit" (BALDWIN 1991, 11).

Another form of irrigation was to draw excavated channels from the big rivers to distant fields or places suitable for constructing reservoirs. Especially remarkable were the skills to construct long canals with extremely low gradients. Today only sophisticated instruments can work with the same precision. The tanks and channels constructed in that manner brought not only benefit for the farmers but also enriched the diversity and structure of the landscape. A diverse fauna of fish, birds and other animals inhabited the tanks, trees were grown along the edges and created a cool environment.

The construction of tanks, reservoirs and irrigation works was considered a meritious act in accordance with Buddhism. Often the clay and soil from the construction of the tank were used to build a *pagoda*, one of the main elements belonging to a Buddhist temple. Therefore the whole complex was called a *Wewa-Dagoba* system, which symbolized the link between material and spiritual wealth (SEELAWANSA 1992, 94).

Live-Stock

"Although the Sinhalese keep cattle and plough their fields with buffaloes they are averse to stock-raising owing to the Buddhist faith, which strongly condemns breeding in captivity or slaughtering for sale or food" (WIJESEKERA 1965, 141). This attitude can still be observed today and the number of Sinhalese farmers keeping cattle is considerably small. But buffaloes cannot only be used for ploughing the fields and for threshing the rice. They form an important component of the system; as farmers were completely dependent on traditional methods of manuring, live stock contributed to the sustainability.

Usually after harvesting farmers allowed their buffaloes and other cattle to feed on paddy residues remaining on the field while at the same time their dung functioned as a fertilizer. Apart from that, dung which accumulated in the buffaloes' sheds was washed away into the paddy fields. At night cows and buffaloes were kept tied to trees in the homegarden, and their dung and urine increased the productivity of the trees.

Of all domesticated animals, the elephant is the most special. The Sinhalese consider them as to be noble beasts. The art of taming and training elephants was highly developed in Sri Lanka. They were used in the construction work of tanks and even *dagobas*, and the clearing of jungle, felling of trees and transporting of heavy loads are some of their numerous tasks. One quite interesting theory says that elephants have been used to stir up the sedimented silt and mud in the tanks in order to bring this fertile water into circulation again. Pigs and poultry are very seldomly found in Sinhalese villages and the habit of drinking milk and eating eggs is not common.

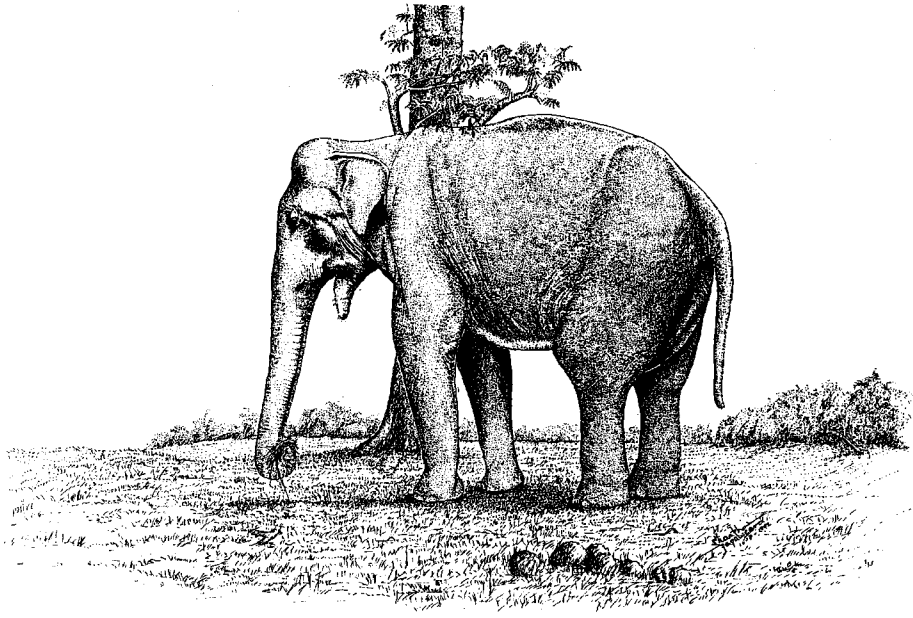


Figure 2.1. The elephant (*Elephas maximus*)

Fertilizer

The art of recycling and reusing different components of the system was highly developed in precolonial agriculture. The techniques used to increase the productivity of the field were sometimes very simple, for instance bathwater and dishwater were usually collected for the paddy field. Mee trees (*Madhuca longifolia*) were planted bordering the fields. The fruits of this tree are eaten by bats which gather around the tree when the fruits are ripe. The droppings of the bats are rich in nitrogen and in that manner the fields are fertilized.

Sometimes green manure, leaves of certain woody or herbaceous plants, was applied. Leaves of vegetables were preferred and during fallow periods cattle-grazing played a major role in sustaining soil productivity (PALM 1988). Additionally the created agro-ecosystem maintained a rich fauna of snakes, small mammals and even fish which contributed considerably to the biological sustainabiltity.

Shifting Cultivation, *Chena*

"With many peasants the proceeds from rice fields did not last for more than half a year, and to make up for the shortage of rice, dry grain cultivation by the *chena* was extensively carried out" (HETTIARACHCHY 1982, 32).

Under this system vegetables, leguminous plants, and various kinds of course grain were grown. *Chena* cultivation was practised on a rotational basis planned by the village council. After clearing the land of small bushes and trees it was prepared for burning. During this time people went hunting and collected fruits and honey. The auspicious day for burning the *chena* was calculated by the astrologer. A successful fire was very important for the cultivation (HAUSHERR 1971).

The seeds for sowing were prepared at home: maize (*Zea mais*), millet (*Panicum sp.*), green gram (*Vigna radiata*), chili (*Capsicum annuum*), pepper (*Piper nigrum*), gourd (*Cucurbita pepo*), pumpkin (*Cucurbita maxima*), cassava (*Manihot esculenta*), hill paddy, *goda wee*, (*Oryza sativa*) and ginger (*Zingiber officinale*). Thereafter small huts were built. During the day women and children observed the cultivated crops to protect them from wild animals. During the night men took their position in the huts. This period was very labour-intensive and had to be alternated with the work in the paddy fields (RYAN 1958).

The productivity of the soil decreases rapidly and after two or three years the area is left and a new chena is burned somewhere else. The forest can redevelop and depending on the availability of land the farmer will cultivate the same plot again after a number of years. The ecological sustainability of shifting cultivation is only assured if the human population is not growing and forest reserves are sufficient. Chena size and rotation periods are also important for ecological viability. Different data show that the cultivation practices were quite different. We find notes describing chena extentions from 5 to 25 acres and fallow periods or rotation periods from 6 to 15 years (HAUSHERR 1971).

Village Homegarden, *Gewatta*

"Paddy cultivation is a business of living, garden cultivation is to receive the good things of a bountiful nature" (RYAN 1958, 28). The *gewatta* provides many of the daily needs for the families. Perennial trees selected over centuries accompanied the villagers' life with many of their benefits. The trees were grown around a small compound where the individual houses were built. Most of the species germinate by wild propagation and are not planted by the farmer. Paddy fields and chena cultivation required intensive labour and therefore the homegarden was meant to "grow on its

own". However, a small effort was made to design the system and the way tree species were combined was diverse:

- useful trees were left standing when the land was colonized;
- some useful trees which did not germinate on their own were planted (for instance Coconut palm, Mango,..);
- seeds and fruits collected in the forest or in other villages were thrown away and sometimes germinated;
- forest species invaded and were tolerated; animals dispersed plants in different ways.

The tropical regions with their diversity of plants seem to be favourable for the establishment of these homegarden systems. This can be called the "lazy man's agriculture", you just spit out a seed and most probably a tree will grow. Though not much labour is needed to maintain the garden, an ample knowledge about different plant uses and requirements is necessary. Throughout the course of time farmers must have selected useful trees from the forest as well as from what was imported from other countries. The origin of many of the tree species, which are now widespread like the Coconut palm, is hard to prove.

The Village Forest

The hilltops and the central highlands were under thick forest cover. Because of the impact on irrigation, forests were not regarded as unproductive land but as a source of water and fertility. Medicines, fuelwood and minor forest products were collected. In the densely populated areas of the dry zone the forest might have been left just to connect adjacent villages. The fact, however, that during those days the rainforests of the wet zone remained more or less untouched should not be forgotten.

2.2. The Shift to the Wet Zone

The collapse of the ancient, hydraulic civilisation (named after their advanced irrigation techniques) started in the 14th century when invasions of Indian troops, Malaria and internal political problems destroyed the advanced agricultural set up. Since then the traditional system of villages, tanks and cultivated land have not been able to be re-established and today`s situation shows, more or less, a disintegrated form of land use.

After the break-down of the dry zone civilisation, the Tamils moved to the North, and the Sinhalese to the Southwest and later on to the Central Province. The hill country was almost always moist and supported a thick luxuriant forest cover. Unlike the dry zone those regions did not suffer from drought periods. In general the original set up of a village as it was practised in the dry zone was not changed but adapted to the new conditions of the wet zone.

The clearance of the valley floors and terracing of the hill slopes for paddy fields must have been difficult work. The terraces were built of mud and stones found nearby and

the system added to the natural beauty of the environment. The streams and rivers coming down from the hills were used for irrigation. Because of the constant water flow sophisticated channels were not necessary. Nevertheless regular supply of rainwater was of cardinal importance to the agrarian society established in the hill country.

The first capital of the wet zone was Gampola and later on, in 1591, Kandy became the royal seat. Traditional land use was practised up until the 19th century because the Kandyan Kingdom established in the central hillcountry resisted the colonial intruders. Only in 1815 was it conquered by the British.

The organisation of villages varied. There was the crown village, *gabadagam*, which the king held for his personal maintainance; there were villages of the aristocracy, *nindagam*; temple villages, *viharagam* or *devalagam*, and free villages, *koralagam*. In each of those villages the land for paddy cultivation was given by the land lord to the villagers in return for service. The Kandyan state can be categorized as an agrarian bureaucracy led by a feudal aristocracy (GUNASINGHE 1990).

There must have been heavy deforestation for the colonization of the central highlands, but the system of forbidden forests, *tahansi kelä* established by the Sinhalese kings, protected the hilltops and other areas which were of importance for irrigation. These regulations, referred to earlier, preserved large areas of primeval forests and created a balance in the ecology of the landscape. They helped to provide adequate rainfall, prevented soil erosion and created a habitat for numerous animals. The elephant for example was a common inhabitant of the highland forests.

Homegarden, *Gewatta*

Land in the village was divided into high lands, *goda*, and irrigated paddy fields, *mada*. Homegardens or *gewatta* were established on the higher slopes where the houses and settlements were built. The vegetables, fruits, and spices that were grown on the small plots surrounding the peasants` homes were important supplements in the peasants` diet. Knox gives a list of trees commonly found in the gardens: areca nut (*Areca catechu*), jak trees (*Artocarpus heterophyllus)*, coconut (*Cocos nucifera*), orange (*Citrus sinensis*), lemon (*Citrus aurantiifolia*), cinnamon (*Cinnamomum zeylanicum*) and many other fruit trees. Another contemporary writer states: "Gardening among the Sinhalese is hardly known as an art; they indeed plant different kinds of palm-trees and fruit trees round their houses, and flowering shrubs about their temples; and they occasionally cultivate a few vegetables, as yams, sweet potatoes and onions in their field; but in no part of the country is a garden according to our ideas to be seen" (DAVY 1969, 206)

These gardens, *gewatta*, became a characteristic feature of the Kandyan landscape. Their diversity and their intricate interrelationship resemble natural forests of this region. Most of these luxuriant gardens are located between valley bottoms and high slopes. The *gewatta* found in the Kandy region (300-900m) are said to be the most diverse and complex of those systems compared to other regions and countries.

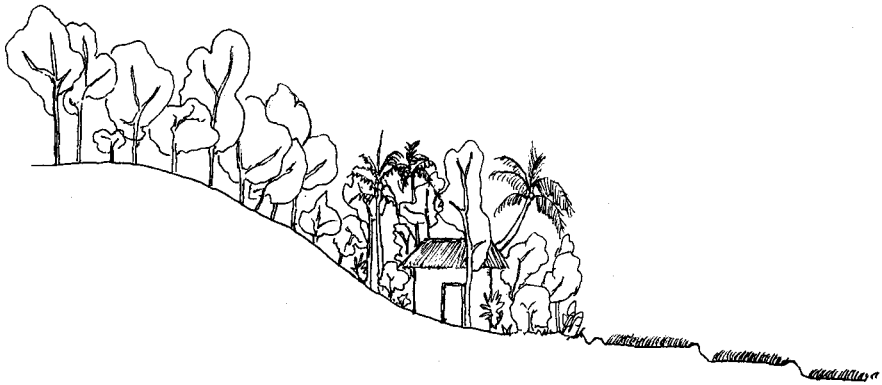


Figure 2.2. Traditional landscape pattern

Shifting Cultivation, *Chena*

Shifting cultivation was practised in the adjacent forest, and the dry grain cultivation there formed a popular subsidiary pursuit. The forest was also a source of supplementary subsistence which provided timber, firewood, honey, medicine, and various other forest products. This component became more important in the wet zone agriculture where products like cinnamon or cardamon were collected from natural forests. These close interactions with the forest and the various products collected formed a major part of their subsistence production. Nevertheless the major system of land use was distinct from unirrigated highlands, *goda bim,* and *mada bim*, where wet rice was cultivated.

Paddy Cultivation

According to the monsoon season and the region of the island the field is prepared for the crop before the Northeast monsoon, *Yala* or the Southwest monsoon, *Maha* season starts. The land is ploughed by the buffaloes, or by hand with a heavy plough, *mamoty*. Once tilled the fields are flooded. During that period the buffaloes again break up the soil. Meanwhile the farmer prepares the seeds. The selected seed paddy is kept dry until six days before use; then it is soaked and the seeds start to sprout. Sowing, in other cases transplanting, is carried out in community work. When the plants are about six inches tall the field is flooded again. After one month the crop is given no more care except for weeding until the harvest (RYAN 1958).

Strong cooperation and solidarity among the villagers was necessary for rice cultivation. The *attam* and *kayya* systems were forms of labour-sharing which characterized and influenced the social structure of the village. The self sufficient society of the hill country could adapt very well to the natural circumstances of the

region. Soil fertility, sustainability of production and biodiversity were preserved over a long period of time (into the 19th century).

2.2.1. General Features of Precolonial Agriculture

The major components, paddy fields, *chena*, village forest and *gewatta* formed the agricultural system of traditional villages. The following criteria characterize precolonial agriculture:

Diversity: Diverse interdependencies between the components guaranteed sustainable productivity throughout the year. The natural vegetation was modified into a cultivated area which still maintained a high diversity of species and lifeforms. The number of plant species utilized by the family was comparatively high and the diverse interactions between man and nature developed into a profound system of traditional knowledge. The diversity of production systems results in stability and minimum risk. Shifting cultivation and *gewatta* form additional income when the paddy harvest fails. The diversity of crops makes the system less susceptible to pests and diseases.

Dynamics: Circular processes make multiple utilisation of the components possible. Many different ecological interdependencies are established. Self-fertilisation is ensured through a continuous biomass-flow.

Resilience: Diversity of species, variability of structure and dynamic interactions among the components result in a resilient agro-ecosystem. The capacity to buffer external threats like droughts and storms increases.

Sustainability: The sensitive adaptation to a tropical environment maintains soil fertility. Multiple use of the different components of the system results in minimum risk and stable production for the farmer. Diverse production systems reduce the problems with pests and diseases to a minimum.

Economic viability: A minimum of external inputs and wise use of resources characterize a "low input" agriculture. Therefore the system is less vulnerable to external determinants like market fluctuations. To a large extent self-sufficiency is guaranteed.

Solidarity: The agricultural practices demanded a strong solidarity among the villagers. The village council, *gamsabhava*, which was composed of the heads of all the families, settled matters of water and land distribution, community work, and the agricultural calendar. Rice could only be cultivated by labour-sharing, *attham*, therefore cultivation could not be separated from strong social relationships. In that context religious practices and the above mentioned rituals played an important role.

Environmental ethics: The practice of *ahimsa* or the non-taking of life within the village community encouraged a non-exploitative relationship between man and wildlife (SENANAYAKE 1993) The establishment of an agricultural system which nourishes human beings as well as other forms of life is an admirable cultural process.

The only crop grown in monoculture was rice but the rich and diverse fauna of fish, birds and insects living in the paddy fields, the fallow periods and cattle-grazing as well as traditional manuring methods could maintain soil fertility and ecological stability. The system of tanks and ponds enriched the landscape. Various trees with manifold benefits were grown along the channels, tanks, and in the homegardens. Rock formations and other special locations were converted into places of worship. The dense forest cover on hilltops and the green belt of homegardens fringing the paddyfields maintained soil fertilitiy and the water cycle. Optimal use of local resources created a self- sufficient society.

Whatever they needed they produced on the land and exchanged among themselves. The little trade in salt and dry fish was carried out by Muslims. The only commercial crop they produced was arecanuts (which they did not grow but which grew on its own) in their gardens. Money was extremely scarce, and paddy or arecanut was the medium of exchange, but a system of barter was more common. They had few wants and were niggardly in their habits. "This is the general picture of the interior of Sri Lanka which caught the eye of the European writers who visited the interior of the island from Robert Knox onwards. Robert Knox wrote in the seventeenth century, 'take a ploughman from the plough and wash off his dirt and he is fit to rule a kingdom'" (HETTIARACHCHI 1982, 41).

The buddhist background encourages people to live a decent and modest life, to earn merits with generous and selfless acts and to avoid "bad karma", commiting acts of killing, stealing and other unmeritious deeds. The way villagers thought was probably strongly linked to the environment. A certain "good" or "bad" behaviour would result in natural phenomena. For instance, rain will only come at the right time when the rituals are observed carefully.

The tropical environment was always experienced as a strong and equal counterpart of man. The self-confidence in science and progress that characterizes Western history during the last few centuries cannot be found in Asia. Therefore one of the characteristic attitudes of traditional agriculture is to establish adaptive mechanisms to the environment rather than dominating mechanisms. Of course burning, harvesting and killing took place but the attitude of the farmer burning the land was not that he was the master but that he was strongly dependent upon his environment. Rituals and ceremonies combined with these acts clearly reveal this attitude.

Rituals and various beliefs express the worldly wisdom that human beings have to respect nature and that they cannot take whatever they wish from their environment. Instead, as is described in a common folk story, man has to return what he takes, like a bee which collects pollen, without harming but pollinating flowers, so bringing prosperity and fertility.

2.3. Colonial Period and Western Influence

2.3.1. Introduction

> *Nature's preservation of the balance of life ultimately benefits even man. Disruption of this by man-made devices is as disastrous to man himself as to other forms of life. Many instances of this may be cited from our own village. When cattle was abundant in our village, there was an abundance of milk, and of dung for the vegetable plots. Consequently dung-beetles multiplied, and so did the iguanas who fed on them. These iguanas kept the beetles and other insects which damaged the vegetable gardens from increasing inordinately. Since vegetables and milk were abundant, the villagers were assured of good health and ease. Perhaps it was man who disturbed this balance. As the use of motor-vehicles reduced the number of cattle in the village the dung beetles and consequently the iguanas dwindled. The vegetable plots suffered inevitably, and as the birds who once came for forage of worms in these plots forsook them for richer feeding-grounds, the scene lost something of its charm and beauty. The dearth of milk made life less healthy and consequently less pleasant for the villagers. This demonstrates how the disturbance of nature which preserves the balance between all living things, can lead to ultimate loss.* (M.Wickramasinghe, Ape Gama)

Colonial influence and the confrontation with the Western world have certainly changed the traditional pattern of life in Sri Lanka. Likewise, the diverse interactions with the environment changed. In the following chapter we will discuss the major developments which replaced traditional land use practices. In order to understand the major changes in agricultural practices it is necessary to give a brief introduction to the colonial history and Western influence on the country.

The breakdown of the last capital of the dry zone, Pollonaruwa, in the 14th century can be seen as the break-down of the irrigation system which has never been restored since. The theories for the cause of the collapse are numerous. It is striking that other civilisations based on irrigation also collapsed during the same period, Cambodia, North-Thailand and Pagan in Borneo are examples. One parallel phenomenon in those countries was the spreading of Malaria which got worse with the negligence of irrigation systems. The rise and decline of these ancient cultures is a complex process and no final conclusion can be drawn with current knowledge.

However, western countries exerted their influence on the island only after the traditional and highly developed system of agriculture had already disintegrated. The shift to the Southwest and the mountainous core of the country brought political instability and economic change. A decline in agricultural activity took place and new economic directions were found.

> For instance with the increased demand for spices in Europe after the Crusades, the island's cinnamon, which grew luxuriantly in the forests of the south-west littoral, became an important item in its export trade. One significant consequence of the growing importance of trade was a slow but perceptible increase in the use of money in the economy (DE SILVA 1981, 89).

As foreign trade grew in importance Arabs settled in large numbers along the coastal areas. The process of opening up also had some effects on Buddhism, which underwent a deterioration in morality and discipline of the *sangha* (order of monks) and suffered under powerful pressure from Hinduism.

2.3.2. The First Contact with the West, the Portuguese Period

> Human perturbation started more than 2000 years ago by the introduction of rice cultivation. However, it was not very destructive and was more or less harmonious until the 15th century, when the first large number of Western people invaded the area for spices. The plantation of monoculture crops started in the 18th century and resulted in the change from the original diversified landscape to the conformable and monotonous one. This trend is still continuing now (YAMADA 1992,51).

At the beginning of the 16th century the first contact with Portuguese people took place. In 1505 they arrived accidentally near Chliaw on the West coast of Sri Lanka. Soon they realized the island's potential in cinnamon production and export and therefore their main interest was not territorial conquest but control of commerce and especially of the cinnamon trade. This provoked hostilities from the Moorish traders who largely controlled the export. But due to their seafaring power and their technological superiority the Portuguese intervention in the islands economy and politics became a permanent feature. The influence was not only confined to the South but also spread to the Jaffna peninsula, which was of strategical importance and of interest because of pearl fishery. Activities of Portuguese missionaries who came from South India established the first contacts with the northern Tamil area, of Sri Lanka.

Rajavaliya, a book on the island's history, describes the arrival of the Portuguese as follows: "There is in our harbour in Colombo a race of people, fair of skin and comely withal. They don jackets and hats of iron, rest not a minute in one place but walk here and there. They eat hunks of stone and drink blood" (Vimalananda 1963). The influence of the Portuguese was restricted to the maritime regions. In contrast the Kandyan Kingdom retained its independence and the Portuguese could not muster the necessary manpower to subjugate it.

Under the Portuguese there was little interference with the existing administrative structure (*rajakarya*). But because of the scarcity of money, the king gave out different rights to the land to various individuals in return for his own rights to extract their services and products. Also the duty to serve the king in exchange for land was

expanded to military service and production of export crops. The tax system brought another change because every farmer was now taxable. Due to these developments the impact on the Sinhalese economy was fundamental. Cinnamon became the main revenue for the state and accordingly dues from the land became less important. The occupation of cinnamon peelers (*salagamas*) grew in its importance. The traditional product of trade, the areca nut (*Areca catechu*), which the villagers exchanged for salt and clothes, was made into an obligatory contribution to the government.

> The coming of the Portuguese to Sri Lanka thus certainly led to greater commercial activity, increasing monetisation of the economy and higher prices for its products,..., but the benefits of higher prices were retained by the state, or Portuguese officials, civil and military, and Portuguese residents engaged in trade (DE SILVA 1981, 127).

Maybe the most fundamental impact was the spread of Christianity which changed the values and social structure of the inhabitants.

2.3.3. The Dutch Period

Due to different tensions the policy of the Kandyan Kingdom developed more and more into a resistance against the Portuguese and at the beginning of the 17th century this included a call for foreign help. Since 1602 the Kandyan king had established contact with the Dutch whose importance in spice trade had grown during the 17th century. They already controlled a large part of the cinnamon trade and the call from the Kandyan king was only too willingly accepted. In 1640 Galle and Negombo were taken by the Dutch and an effort was made to bring the cinnamon growing areas under Dutch control. They succeeded in 1658 when the Dutch conquest over the Portuguese was completed. In the period of 1665-70 they had established a firm control over the entire coastline, trade as well as traffic was in their authority.

"The export of elephants, areca, chanks and pearls was now declared a monopoly of the Company, as was the import of cotton goods, pepper, tin, zinc and other minerals. Rice was the only major item of import left out" (DE SILVA 1981, 138). These regulations brought interferences with the Kandyan kingdom which remained independent. The trade between the Kandyan Kingdom and South India in areca, pepper and cardamom was disrupted and controlled by the Dutch; on the other hand Dutch assistance was required in the form of ships and boats by the Kandyans. Taking all factors into consideration the relationship between Dutch and the Kandyan Kingdom can be characterized as a policy of co-existence. Both parties were aware of their mutual dependence.

Nevertheless the impact on the local economy was a continuation on what the Portuguese had started. The first plantations of cinnamon were established in 1769 and by 1771 they seemed to work economically, resulting in the establishment of other plantations along the littoral. By the end of the 18th century the world supply of cinnamon was produced in Sri Lanka. Coffee was introduced as a garden crop in 1722

but the production was quite negligible in the beginning. Coffee, pepper and cardamon became an important source of money for the people. The process of monetisation and greater familiarity with cash transactions was the result. Already in the early stage of Dutch rule emphasis was placed on promotion of subsistance agriculture and rice cultivation. For that purpose the restoration of the irrigation system was necessary but these efforts failed and rice had to be imported to a great extent.

"In fact the substantial achievement of the Dutch in canal-building completely overshadowed their work in irrigation, and these canals were among the most notable contributions to the island`s economic development" (DE SILVA 1981, 170). Besides that the most lasting contribution was the establishment of the Roman-Dutch law. The customary law of the Sinhalese could not withstand this innovation. The social changes and the impact on marriage, private property and inheritance were inevitable. Buddhist and Hindu religion was somehow tolerated but worshipping at the temple was prohibited in towns and the administrative officers had to convert to Calvinism.

2.3.4. The Arrival of the British

In 1762-5 increasing tensions and irritations led to warfare between the Dutch and the Kandyan kingdom. Again the Kandyan kingdom sought foreign assistance which was the reason for the first contacts with the French as well as the British. At the same time the Anglo-French struggle for control of India cast a long and ominous shadow on Sri Lanka (DE SILVA 1981). The harbour of Trincomalee became strategically important for both countries. After the Dutch joined in armed neutrality with the French against Britain the war between the Dutch and the British started in 1781. Due to these developments the desire to gain influence on Sri Lanka became an important theme in Britain`s foreign policy. Finally, between 1796 and 1802 the island came under the administration of the East Indian Company which resided in Madras and in 1802 Ceylon was made a colony under the British Empire.

> The traditional Kandyan policy of seeking foreign assistance to oust the European power established in the maritime regions had on this occasion led to the substitution of a very powerful neighbour for a weak one. Should this new neighbour ever decide that the independent status of the Kandyan kingdom was in any way an obstacle, let alone a threat to its territorial ambitions in South Asia, it had the resources- unlike the predecessors in control of the maritime regions of Sri Lanka, the Portugese and the Dutch- to subjugate that kingdom (DE SILVA 1981, 187).

In 1815 this came true and with the annexation of the Kandyan kingdom the most significant political and administrative change occurred. For the first time the 2400 year old tradition of Sinhalese kings was broken and the entire island was under one power - the British. The starting point for several economic and social changes was created. Once again between 1817-1818 an attempt was made to drive out the British when a rebellion sparked off and quickly spread throughout the Kandyan Province.

The rebellion was suppressed and the entire century was characterized by the colonial administration of the country which shaped the island's development irreversibly. The impact on economy and agriculture can be summarised in the following statements:

- The successful establishment and expansion of plantation agriculture.
- Transformation from traditional ways of trade and exchange to a market economy.
- All chena and forest land formerly in the Sinhalese kings' possession fell to the British crown.
- Chena cultivation required a special permit.
- Establishment of an education system based on Western principles.
- Grain tax and changes in land tenure.
- Revitalisation and restoration of the ancient irrigation systems.
- Improvements of infrastructure, building of roads and railways.

The above mentioned factors show that the transformation of the traditional society could not be resisted and was irreversible. To describe the process in detail would mean to go beyond the limits of this book. Therefore we confine ourselves to the major changes in agriculture.

2. 3.5. Development of Plantation Agriculture

"A plantation or an estate can be described as a large parcel of land on which hundreds of labourers are regularly employed in the systematic cultivation of a single cash crop for sale in the market" (Bandarage, 1985,66).

The first plantation was established by the Dutch in 1769 to secure enough supply of cinnamon. But cinnamon plantations always remained a small-scale enterprise. The first crop grown on a large scale was coffee. The cinnamon plantations established earlier were never expanded to that extent. Up until 1830 the production of coffee was mainly in the hands of small holders. They grew coffee in their gardens surrounding their village homes, often they neglected the bush during its growth, and harvesting as well as processing was not done in a systematic manner. It was not easy to convince farmers to grow coffee more intensively. And in 1848 strong resistance against tax increases and a reduction of prices developed. Nevertheless between 1850-1870 a coffee boom occurred due to a greater demand in Europe as well as other factors. This "coffee mania" came to a sudden end and because of a fungus (*Hemileia vastratrix*) the entire production collapsed, leaving nothing but acres of diseased coffee trees, deforested hills and disoriented, hopeless farmers.

In the 1880's coffee was replaced by tea. This was much more labour- and capital-intensive. Tea could be grown in higher areas and soon the former chena areas were converted into tea plantations. Several conflicts arose because the farmers were clinging to their traditional rights to use the land for collection of firewood and medicine.

> It is well to remember that recognition of users` rights to land was not a feature peculiar to Kandyan society. It was characteristic of precapitalist societies in general, and the clash between users` and owners rights is an inevitable outcome in the transition from precapitalist to capitalist forms of land tenure (BANDARAGE 1985, 91).

Due to different factors including these conflicts the plantation areas were expanded to higher elevations, and the forest, for so long untouched, was converted into plantation land. A brief study of the history of tea plantation in Sri Lanka shows that the time of rapid expansion of tea ranged between 1867-1900. Because of the climatic requirements of the tea plant the area under cultivation was restricted to the Southwestern plains and the central highlands (MARBY 1971).

Unlike tea and coffee, coconut plantations (*Cocos nuciferea*) have always remained as local enterprises of smallholders. The long period of ten to fifteen years before the trees yield might be one explanation for this phenomenon. Therefore the plantations were largely local enterprises both in terms of labour and ownership. The Europeans influenced only the marketing. The coconut is often referred to as the tree of life and it provides for many of the daily needs of the rural population. Food, drink, shelter, domestic utensils, medicine, rituals and religion. "In fact, one writer remarks that the coconut tree directly and literally serves the Sinhala peasant from his cradle to the grave" (HETTIARARCHCHY 1982, 78). The dissolution of traditional systems, the introduction of wage labour and growing urbanisation were some of the reasons for the conversion of the tree of life into a commercial crop.

Rubber (*Hevea brasiliensis*) was introduced at the end of the 19th century but the cultivation started mainly at the beginning of the 20th century. Rubber required a lower altitude than coffee or tea but a higher altitude than coconut. It was cultivated by local small holders as well as by large scale plantations owned by foreigners. Most of the plantations were prosperous, since the demand for rubber was increasing.

By the end of the 19th century the general features of the landscape had changed completely: At sea level and up to 300m we find coconut plantations, rubber was cultivated in areas up to 800m and tea covered an area from 300m up to 2200m. The hilltops and mountain areas were converted into forest plantations which started around 1890 in order to cover timber and fuelwood demand. For that purpose fast-growing trees like eucalyptus, pines and acacias were introduced.

The natural forest cover of the central highlands had diminished quickly and forever. Amongst other impacts this caused major changes in climate. Rainfall decreased and streams dried up. The large herds of elephants earlier found in the mountain forests were slaughtered and disappeared (WERNER 1987) and the rapid loss of many wild plants and animal species continued. Traditional agriculture had been rather neglected and rice had to be imported in large quantities. Large areas began to loose topsoil, became impoverished and were abandoned to become fire managed grass lands

(SENANAYAKE 1993). The traditional system of land tenure was transformed and land concentration in the hands of a few families became possible.

But by the end of the colonial period the lessons of land degradations had been learned and the landscapes were managed to sustain at least some elements of ecological stability. Shade trees, windbreakers, contour planning, terracing and draining were embarked on. The landscape of the village took on a different character and the traditional *gewatta* system was enriched with many exotic species with high utility (SENANAYAKE 1993).

All this characterizes the island's situation at the beginning of the 20th century. The political developments during the last 90 years are complicated enough to be discussed at length but we will just briefly state the main points of interest for our purpose.

2.4. Postcolonial Development

2.4.1. Introduction

> *Study how a society uses its land and you can discover what its future will be.*
>
> E.F.Schuhmacher

Sri Lanka gained independence in 1948 under the leadership of D.S. Senanayake. It is worth mentioning that the transfer of power in Sri Lanka was smooth and peaceful unlike the catastrophies in the rest of the former British colonies in South Asia. The first period of independence was a period of economic growth. The development of traditional agriculture was especially strengthened through irrigation projects and peasant colonisation. The economic crisis in 1960, the arising minority problems, the break-out of the civil war in 1983 and the troubles caused by the JVP (Peoples` Liberation Front) and the LTT (Liberation Tamil Tigers EElaam) up to the present, including the assassinations of political leaders, have exhausted and distressed the country`s economic and political resources, since then the ecological problems have increased as well and the problems the country faces today are manifold.

2.4.2. Characteristics of Postcolonial Agriculture

The plantation industry has undergone major changes since independence. In 1972 the land reform implemented by the Bandaranaike government had a major impact on the management of plantations. The nationalization finally resulted in bad management, decreasing soil fertility, loss of shade trees and decreasing yields. Biologically, this period saw a tremendous increase in the input of biocides with catastrophic effects on the environment (SENANAYAKE 1993).

The decline of natural forest after independence was immense. The forest plantation established consisted mainly of exotic species (*Pinus* and *Eucalyptus*) which do not serve the same ecological functions as the indigenous forest. The argument used for the establishment of large monocultures with exotic species is that indigenous trees are said to be too slow in their growth and not adequate for eroded sites. These arguments are used up to the present and the challenge to develop a sustainable plantation economy is still not fulfilled.

After independence new cash crops came out: vegetables and tobacco. Today farmers can earn "quick" money with these crops but ecologically it will lead to a dead end. Soil erosion, intensive use of chemicals and high input of labour and energy are not sustainable. The traditional and basic agricultural practice of paddy cultivation has also been modified by modern developments. Old varieties have diminished; the new improved varieties (HYV`s), chemical fertilizers, pesticides and herbicides have

promised high yields and good income. The "sacred crop" of the ancient Sinhalese has also become a "cash crop".

Population growth, especially during the last decades has created another pressure on natural resources (in 1871 2.4 millions; in 1986 16.8 millions and by the beginning of the next century it should reach 20 millions) (BALDWIN 1991). Today Sri Lanka is one of the most densely populated countries, second only to Bangladesh. It is also one of the poorest countries and there seems to be no solution to the economic difficulties.

One of the reasons starvation, the most bitter form of poverty, has not yet expanded is the still-existing subsistence agriculture and the productivity of homestead gardens, found in the rural areas of Sri Lanka. Today farmers` dependency on these gardens has increased tremendously. A decrease in the available land, the diminishment of shifting cultivation, price fluctuations of cash crops and other components are responsible for this development.

The traditional homegarden, *gewatta*, plays an important function in the food supply of local people. Up to the present day the fuel wood demand (80-90%) can still be obtained without monetary transactions. (BALDWIN 1991). These gardens take up 629170 hectars of the land (13.5% of the total area) and their productivity, which is one of the main topics of the practical part of this study, is an essential contribution to the self-sufficiency and dignity of the villagers` lives today (SURVEY DEPARTMENT, 1988, 121).

This excursion into history and recent development leads us back to the original question, the development of a sustainable agriculture. The following elaboration on the *gewatta* system found in Sri Lanka`s hill country will reveal concepts inherent in traditional agriculture which can be valuable for an alternative development. The *gewatta* system is characterized by low input of energy and resources, production of items adapted to the natural and socioeconomic setting, optimization of energy flow and turnover rates of matter and nutrients.

One characteristic feature of sustainable production is the strong bond between ecology, economy and culture. The *gewatta*, because of its close attachment to family life, still manifests a vivid link between these three components. Cultural and religious attitudes, ecological features and economic criteria form a unique system which can be used as a model for a sustainable relationship between man and nature.

PART 3

A Detailed Ecological Study

3.1. Study Area

3.1.1. Introduction

> *A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.*
>
> (LEOPOLD 1987, 224)

The small island shaped like a teardrop in the Indian Ocean has often changed its name often during the long history of civilisation. In the Hindu epic, Ramayana tells of Rama`s beautiful wife, who was carried away by the evil king of Lanka. The Romans called the island ´Taprobane´, the Muslim traders talked of ´Serendib´, the Portuguese called it ´Ceilao´, which changed to ´Zeilan´ under the Dutch and ´Ceylon´ under the British. The traditional name Sri Lanka was reintroduced with independence.

Sri Lanka is situated at the southern tip of India and in many respects it is related to the subcontinent, as most of its inhabitants immigrated from India from about 500 B.C. Presently the population is estimated to be nearing 17 million. The great majority (75 %) are Sinhalese. The Tamil population accounts for 18 % and the rest (7 %) includes Moors, Burghers, Eurasians and others. The population is concentrated heavily in the southwest and central regions of the island and in the Jaffna Peninsula. Most Sri Lankans live in villages (BALDWIN 1991). The Democratic Socialist Republic of Sri Lanka is a unitary state whose legal and administrative structure is based on its republican constitution. Sri Lanka consists of 25 administrative districts and nine provinces.

Geography

The island is located close to the equator between the latitudes 5°55` and 9°51`,enclosing an area of 66000 km², which is comparable in size to the Netherlands. The central hill country rises in the southern part of the island surrounded by low-lying coastal plains and the flat northern areas. The mountain zones, divided into highlands and midlands occupy a fifth of the island and rise up to an elevation of 2524 m (Piduratalagala mountain) and 2224 m with the Adams Peak.

The central massif of the mountain zone is located in the southern central parts of the island forming the Great Southern Escarpment. Two other components, the *Knuckles* range in the northeast and the *Sabaragamuwa* hills in the southwest complete the entire mountain zone (FERNANDO 1968). The intensive studies of the present investigation have been confined to the Central Province in the centre of the Island. The characteristic feature of this mountain zone is the great contrast in relief and physiography which causes different climatic patterns. A brief introduction into geology, climate and natural vegetation of the central hill country will give a better understanding of the main biotic parameters which can be seen as an essential component of the *gewatta* agro-ecosystem.

Geology

The island was separated from the Indian Deccan Plateau by a great rift in the continental shelf. The central mountain core is entirely composed of solid crystaline rocks of the Precambrian age. These crystalline rocks can be divided in two major parts: the Vijayans and the Khondalite`s or Highland series. The latter are confined to the hill country of the island. "The Khondalites are metasedimentary, they are formed by metamorphoses of sedimentary rocks. [..] Various combinations of quarzite, charnockite, and schists tend to repeat themselves wearily, mile upon mile, in the Highland Series. The Khondalite bear Ceylon`s chief economic minerals: mica, gems, and graphit." (FERNANDO 1968)

Soils

The weathering of rocks by physical or chemical processes results in various formations of soils. Because of their situation in the tropical belt, soils in Sri Lanka are characterized by rapid weathering, and rainfall and temperature are important for variations. The major soil type, however, found in the central plateau has been classified as Reddish Brown Latasolic soils and Immature Brown Loams (PANABOKKE, 1967).

Climate

The climate of Sri Lanka is characterized by the relative monotony of tropical regions. It is important to keep in mind that the "seasons" in the tropics are very different from the seasons of the temperate zones, as they are created by and connected with wind systems: in the case of Sri Lanka, the north-east and the south-west monsoon (MARBY 1972).

Because of its specific topographic conditions, Sri Lanka is divided into two major climatic regions, the "wet"- and the "dry zone". Both are characterized by rainfall patterns caused by the southwest and northeast monsoon. From May to September the SW-monsoon and from December to February the NE-monsoon have their main influence on the climate. The mountainous relief results in a `diversification` of these climatic conditions according to orientation and elevation of the valleys and peaks. This is to say that each single valley receives rainfall according to elevation and position (luv- or lee-side). The rainfall pattern not only varies in the course of the year but also from one year to the other. Therefore the clear distinction of climatic regions and boundaries is a difficult task. However, the central region belongs mainly to the wet zone with different transitions to the dry zone, recently identified as intermediate zone. Mean annual rainfall in the central part of the island is 2500 mm in this region and declines rapidly towards the northwest and southeast. The mean annual temperature of the mid country is about 15 C°, however, daily temperature ranges are more significant than the seasonal change.

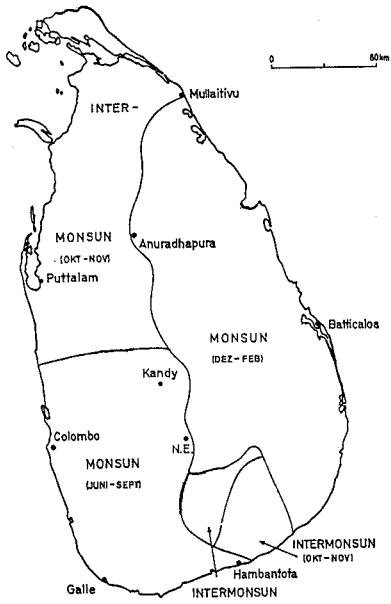


Figure 3.1. The rainfall and monsoo pattern in Sri Lanka as recorded by Domrös (DOMRÖS 1969).

3.1.2. Natural Vegetation

Sri Lanka's abundant richness in natural capital is well known throughout the world. The country has the highest biological diversity (number of species / 10,000 km2) among all Asian countries. The list of species which are endemic to the island is long. This high number of endemic species may be explained by the fact that the island was once attached to the former great Antarctic continent Gondwanaland. About 80 million years ago the Indian sub-continent broke off and moved towards the Asian plate. During this time the Sri Lankan island broke off again and was separated long enough to allow the evolution of distinct forms of life. A further explanation for the high biological diversity is the variety of habitats. Various eco-systems can be found in Sri Lanka, ranging from dense tropical rain forests to coral reefs, from mudflats to savannahs or from mangroves to sand dunes.

Such optimal conditions have, however, been threatened during the last century , as recorded by data material of the last decades which present less hopeful facts for the future (GUNATILLEKE 1990). Sri Lanka has faced a considerable population growth from less than 4 millions at the beginning of this century to roughly 18 millions in the early 1990ies. A growing population needs additional land for

intensive agricultural use - basically at the cost of natural forests. While the population has grown by 500 percent this century, the natural forest cover has shrunk dramatically from 70 percent at the beginning of this century to not more than 20 percent at present. Hence, rainfall runs off much faster and removes the soil from the sensitive hill regions. Climatic extremes are not buffered anymore and floods as well as droughts are the consequences. In addition, environmental degradation as a result of pollution, such as the degradation of ground and surface water, can be observed increasingly.

The loss of biological diversity can be illustrated well by the fate of the greatest living symbol of the island's biological resources, the Sri Lankan elephant, *Elephas maximus*. As an indicator species the elephant provides an opportunity for baseline monitoring of the environment. An indicator species in trouble signals malfunctions in an ecosystem. The number of wild elephants has declined from an estimated 12000 animals at the beginning of the century to roughly 2000 today. The decline is only partly due to poaching activities, a colonist's pastime[1], which occurred in the early decades of the century. The main factor is considered to be the depletion of their living space.

The situation was different when Robert Knox described his impressions on his first journey in the 17th century: "As you travel through this country there is nothing to be seen but woodes, the trees growing over the roads so that it is difficult to them who are not well acquainted with the country to find the wayes" (KNOX 1989, 4). At that time the dominant natural vegetation of the central province was the luxuriant tropical rainforest, and its characteristic formations according to elevation and climatic conditions were still common. Recent investigations by different scientists on forest reserves and other natural plant communities scattered over the hill country suggest the presence of the following vegetation cover types in Sri Lanka.

- Tropical mountain rain forests
  - Calophyllum zone
  - Calophylum walkeri-Syzygium community
- Tropical sub-mountain forests;
  - Myristica-Cullenia-Aglaia-Litsea series
  - Shorea-Calophyllum-Syzygium series
- Tropical wet evergreen forests
- Tropical moist semi-evergreen forests;
  - Filicium-Euphorbia-Artocarpus-Myristica series
- Riverine and gallery forests.
- Savannah forests
- Patana grasslands
  - Upper wet patana grasslands
  - Humid zone dry patana grasslands

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[1] Samuel Baker, a British colonist, became famous in Sri Lanka with his slogan "I will not have breakfast before having killed at least one elephant"

3.1.3. Land Use

The island has been shaped and influenced by man and his activities since about 500 B.C. The land use systems of the island show a clear distinction between low-country and up-country agriculture. Paddy cultivation, however, is possible in all areas except mountainous rain forest and wet patanas below 1200m. The main belt of paddy cultivation stretches along the south-west coast and extends to the Anuradaphura area and Jaffna. In Sri Lanka, paddy is an important crop both in terms of land use and dietary importance, covering 11.4% of the area.

Chena cultivation is probably the oldest form of agriculture in Sri Lanka, it still continues today in the dry regions of the island. It involves forest clearing and cultivation for one or two seasons, followed by abandonment and forest regeneration. In 1984 the Land Use Division of the Irrigation Department estimated *chena* land to be about 1.2 million hectares.

Forest gardens or *gewattas* have been a dominant form of land use on the island for centuries. Today they occupy 13.5% of the total area of the island. In the intermediate zone they cover 13.1% of the land and in the wet zone 24.2% (SRI LANKA SURVEY DEPARTMENT 1988). They constitute one of the most important forms of land use. The *gewatta* system is found in sheltered valleys, adjacent to the paddy land and along slopes. Today the *gewatta*'s contribution to conserving the country`s biodiversity, to the protection of soils and the improvement of climatic conditions cannot be ignored.

Besides these traditional land use systems plantation systems are an important feature of the island`s economy. Rubber plantations are found in the wet low-country up to an elevation of 700m and tea plantations up to an elevation of nearly 2300m, covering an area of 4.3%. Due to various factors such as poor management, increasing plant age, adverse weather, declining soil fertility, inadequate replanting and nationalization following the Land Reform Laws (1970) tea production is declining and the economic importance has diminished significantly. Today agriculture as well as urban and village development show considerable impact on the natural forests. Yet the latter only covers a small part of the country,12.4 % in 1983 (BALDWIN, 1991).

3.2. Selection Criteria for the Study Area

Geographical region and specific topographic and climatic conditions of the study area are representative of the wet and intermediate zones of the Central Province. The study areas belong to the central hill country mid-elevation slopes, reaching from 400 m up to 1000 m. Climatically the area belongs to the wet and intermediate zone with average rainfall ranging from 1500 mm to 5000 mm. Within these wide variations the luxuriant vegetation of the traditional *gewatta* system is found. Most of the gardens surveyed were inherited from previous generations and were over a 100 years old.

The following points aided the process of selection:

1. The main area for our research was Kandy and Pilimatalawe where the traditional „Kandyan Homegardens" are very popular. For a better understanding of the modification of the system under different environmental and social conditions other sites were selected for comparative investigations.
2. Priority was given to traditional villages in remote areas where facilities like roads, market access, electricity or public transport were underdeveloped. The hypothesis was that the *gewatta* systems found in those villages where subsistence production was still essential, would be more diverse and complex.
3. Another important criteria for the selection process was the proximity of natural forest.
4. To work in those villages a basis of confidence between farmers and the research group was essential. Therefore we selected villages already employed in different projects:

   Hapuwela (Nuwareliya Disrict) was already part of the GTZ - Upper Mahaweli Watershed Management Project.
   Pitekele (Ratnapura District, situated along the border of the Sinharaja Man and Biosphere Reserve) is included in different surveys. Cynthia Carol, Havard University, was working on a study on time allocation methods which gave additional support to our research on homegardens.
   In Deniaya (Galle District) we received assistance from the Forest Department.

Another source of information used to select field sites was the Forest / Land Use Mapping Project. The project is funded by the Overseas Development Agency and provided valuable information about areas with rich and productive *gewatta* systems. Pujapitija and Harrispatu (Matale District) were selected according to their suggestions.

Personal discussions with experienced scientists like Prof. Dassanayake helped us to choose the Pinnewela (Kegalle District) and the Knuckles (Matale and Kandy District) Illukumbura, Hunnasgiriya, and Meemura areas for our research.

We thought that forest species were more likely to invade gardens when they are located close to natural forest. Species composition, structure and complexity of the *gewatta* system were assumed to be richer. Likewise the different transitions of natural forest to the *gewatta* system would be more comprehensible. Therefore we decided to work near the Sinharaja forest and in the Knuckles region. Data available on these forests types could also be used for reference.

Six sites with a total of 158 *gewatta* in different parts of the wet and intermediate zone were selected accordingly.

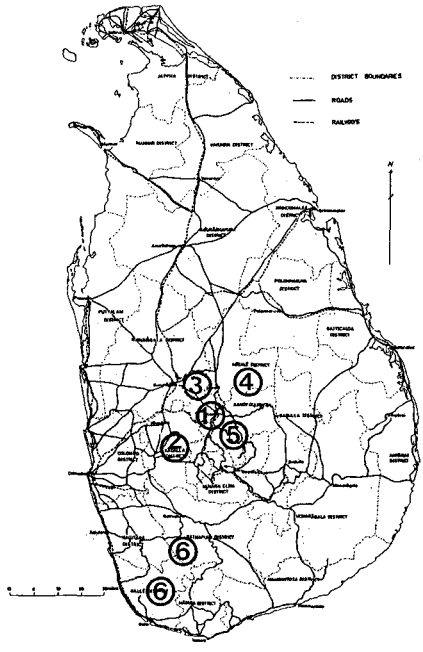


Figure 3.2. Sri Lanka in the late twentieth century (DE SILVA 1981)

- **SITE 1**: Kandy District: Kandy town area, Pilimatalawa (7°16`N, 80°24`E) Arambegama, Kiribathkumbura, Gangoda, Govindele, Hulankande, Ielekotte and Kattapittiya, Marathugoda, Alagoda
- **UDAWATTEKELÄ FOREST:** The forest is located north of Kandy town and covers an area of 84 ha, today it is declared as a "Man and Biosphere Reserve". We used the forest to compare our findings of the *gewatta* system with a forest ecosystem. It can be called semi-natural because 21 ha were replanted between 1922-1936 after extensive. The vegetation of *Udawattekelä* can be categorised as typical of a tropical lowland rainforest, (*Artocarpus. Pometia, Filicium* zone, GRELLER AND BALASUBRAMANIAM 1980).
- **SITE 2**: Kegalle District: Pinnewela (7°19`N, 80°24`E), Hataraligatta, Sangarajapura
- **SITE 3**: Matale District: Bokkawela (7°24`N, 80°33`E), Pujapitiya (7°23`N, 80°35`E),
- **SITE 4**: Matale, Kandy District, Knuckles: Illukumbura (7°23`N, 80°46`E) Telgamuwa, Kirimatiya, Kirigankumbura, Karambagedia, Meemura (7°26`N, 80°50`E)
- **SITE 5**: Nuwareliya District: Hapuwela (7°10`N, 80°46`E)
- **SITE 6**: Ratnapura, Galle District: Deniaya (6°20`N, 80°33`E), Kakundeniya, Katawella, Narandolla, Dombagoda, Lankagama (6°21`N, 80°28`E), Horragala and Pitekele (6°26`N, 80°25`E)

3.3. Methodology

The methodology used for the general survey of the *gewatta* system took into account different considerations:

- It was our objective to characterize the diversity, nutrient cycle, management and traditional use of the *gewatta* system.
- A typical traditional *gewatta* was identified as at least one generation old, rich in plant species and resembling natural forest in it`s physiognomy (3-4 canopy layers, closed canopy cover >70%, complex vertical stratification and non-regular horizontal distribution) (Perera, 1991).
- Another important criteria was a good relationship with the farmer. Using the information available from farmers and rural people we could develop a more profound understanding of the *gewatta* system and eliminate repetitive investigations.

3.3.1. Floristic Survey

The general procedure included a complete plant inventory. Usually the farmer was asked to show his garden, and while walking through the site, species were listed; usually the farmer was really helpful in showing us the garden and providing us detailed with information about different uses of plants.

Sinhala plant names were recorded and species unknown to us were collected and conserved for later identification in the herbarium of the Royal Botanic Garden Peradeniya.

General observations on phenology and zoology
Regular visits to the study sites enabled us to make observations on phenological changes of the vegetation. Some trees around the established litter traps were marked and their phenological status described (i.e. blooming, fruiting, shedding of leaves, or other notable observations).

Bird life was observed regularly every month during the morning or evening hours. These observations were just a preliminary step towards a holistic approach to the ecosystem. A zoological survey on the *gewatta* system would especially bring synecological results as the gardens were obviously an optimal habitat for various kinds of birds. The food chains established ultimately benefit the farmer as the problem of pests and diseases is minimized.

3.3.2. Farmers` Survey

The help and reliabilty of the farmers was necessary for our approach. Research on rural people and their affinity to the environment makes it necessary to start investigations on a broad basis. One of the interesting results of our survey was that a

narrow set of questions and investigations will not lead to a fruitful communication between scientist and farmer. Someone mainly "hunting" for data might overlook some of the hidden messages. Therefore, after gaining some experience out in the villages we found it more profitable for the success of the study to spend some time living in a village, listening to all kinds of discussions instead of giving priority to our data collection and questionnaire. This process was time consuming but it resulted in a profound understanding of rural life. This approach implies a flexible program and the possibility of modification and change. The process of interacting with the farmer can be described as follows:

- Establishing a relationship with a known family in the village (mostly through institutions like the forest department, foreign aid projects, or through personal contacts).
- Arranging a certain period of time to live with the family, according to the farmers` availability (between one and two weeks).
- Discussing and explaining the research objectives with the farmer. Generally, people understood very quickly what our purpose was and they were extremely helpful in selecting gardens and referring us to other farmers.
- A questionnaire was used to record the basic information characterizing the garden: size, age, management practices such as fertilizer applications, manure, compost, weeding, pest and disease control, and livestock components were registered.
- Questions concerning the cultural, social and economic situation of the family were partly answered through observation, partly through a process of discussion. To give a small example: it was not an appropriate question to ask the farmer about his religion but observing the house and drinking a cup of tea with the farmer one could easily get an impression of the religious background. Buddhist families always had a small shrine with oil lamps, flowers and an image of the Buddha. Small occurences such as whether this shrine was decorated with fresh flowers or illuminated by electric light create a general picture of the families` religious behaviour. Again it was not our objective to compile a statistical data base on different shrines but the overall picture and the farmers` attitudes could be understood more comprehensively.
- Observations clarified the following points: The number of family members working in the homegarden, the amount of time spent on agricultural activities in the garden, the main objectives of the garden (food production, additional cash income, or just the maintainence of traditional ways), the important products harvested (timber, fuel, fruits, spices, vegetables, medicinal plants,..), the process of marketing (whether a trader came to the farmer, or whether the farmer went to the market himself,..) religious background, attitudes towards indigenous aryuvedic medicine and utilisation of medicinal plants, attitudes towards the garden, and plans of development or change.

3.3.3. Structural Features of the *Gewatta* System

For the investigations on the ecological characteristics of the *gewatta* system, representative plots were selected. Following the requirements suggested by Müller-Dombois (MÜLLER-DOMBOIS 1974):

1. The plot should be large enough to contain the most important species
2. The habitat should be equally distributed within the stand area.
3. The plant cover should be as homogenous as possible.

The vegetation of the *gewatta* was investigated with the Count-Plot Analysis (Müller-Dombois, 1974). Plot size varied according to the scale of the garden between 100m2 and 400m2. The plot was always established in the part of the garden most distant to the house where usually the most undisturbed conditions were found. Close to the house ornamental plants, herbs and vegetables dominate, whereas further away human influence is limited to harvesting and some minor work, which allows the natural vegetation to co-exist with the planted species. The degree of naturalness is therefore partly dependent on the size of the garden. For an average garden of 5000m^2 we used the plot size of 20m by 10m. Within these plots the girth of all woody species (above a diameter class of 10 cm) was measured at the height of 1m where most of the multistemmed trees were branching. The height was documented as well. One tree was measured with an instrument (Blume-Leiss) and the rest were estimated accordingly. Basal area and density were used to calculate dominance relations. According to North American studies, tree basal area can be used as an estimate of dominance (CURTIS 1959, WITTHAKER 1970).

In addition, profile-diagrams were drawn-up frequently to describe the structural features of the garden. Our method here was the exact measuring and mapping of a 10m to 1m profile in vertical and horizontal arrangement of trees. The undergrowth was characterized by mapping small plots measuring 1m by 1m, whereby every plant was documented. This procedure was abandoned after the first 30 gardens because it was too time consuming and the variations found in the ground cover varied too much according to the effects of light. Later on the undergrowth was estimated in percentage of ground cover and the species were recorded.

This general procedure was used for most of the 158 gardens surveyed. Sometimes farmers did not have enough time to wait for us to establish a plot, sometimes the garden was too small for plot measurements; in the southern villages, near the Sinharaja forest, plots could not be established because gardens were restricted to a narrow belt around the house only.

A total of 88 plots between 100m^2 and 400m^2 were sampled. For the forest plot size varied from 400m^2 to 1250m^2.

3.4. The Indigenous Village Homegarden "*Gewatta*"

3.4.1. Introduction

"Trees are part of our family" A Chipko Woman from India

For any visitor of the island the intensity and impressiveness of tropical vegetation will be a powerful experience. To travel from Colombo towards the hill-country is an immersion into a multitude of different scenes. Paddy fields alternate with forest-like patches of various palms and trees, small rivers and streams feed paddy fields with water, jungle is interrupted by the occasional village. These sights will dominate the first impression.

The unsuspecting traveller will consider the forest-like vegetation of the homestead gardens fringing the paddy fields as natural forests and jungles. The superficial observer will not go further in his investigations. He will not even have a vague suspicion that this "jungle" full of palm trees and densely growing fruit trees is a man-made garden, an age-old form of agriculture.

The fascinating insight that this "wilderness" can be utilised by man and, even more surprisingly, that it creates a liveable environment sustaining many of the daily needs of rural people, remains obscure for many of the island's visitors.

There are many different terms which characterize this traditional garden system: "Kandyan Gardens or Kandyan Forestgardens" (JACOB, ALLES 1983, 269); Kandyan Homegardens (WICKRAMASINGHE 1991); Forestgardens (EVERETT 1991, NUBERG 1994). The Singhalese term "*gewatta*" can be translated with *Ge* which means home and *watta* which refers to garden or plantation.

These gardens have been described by several writers and scientists. The following statements might give an impression of these man-made forests, though it is difficult to capture the entire complexity of the *gewatta* system in words only.

"A conspicuous feature in native agriculture throughout southern Asia, which often offends the eyes of those who have a superficial acquaintance with European agriculture, is the wild jungle-like mixture of fruit trees, bamboo, vegetables etc..., which forms the average native garden" (BOMPARD et.al. 1980).

"The beautiful effect of the landscape found in the mid-elevation hills of Ceylon is that it takes on a role somewhere between garden and forest, between culture and nature. Sometimes one might have the impression of being inside a beautiful forest, surrounded by tall and splendid trees which are overgrown by various climbers. A small hut, however, partly covered by a breadfruit tree, or playing children, will remind us that we are inside a Ceylonese garden. The distinctive harmony between nature and culture is also revealed in the human component of these forest-like gardens" (HAECKEL 1884, 123).

"Kandyan Gardens or Kandyan Forestgardens of Sri Lanka represent a traditional system of perennial cropping which has been in practice for several centuries. It is essentially a system of mixed cropping with a variety of economically valuable groups of tree crops such as spices, fruits, medicinal plants and timber species" (JACOB, ALLES 1983, 269).

"...A forest-garden can be defined as a farming system which supplies all or most family´s basic material requirements from a small area of highly diverse tree, palm and vine crops and from short-term ground-level crops beneath these tree-crop canopies." (MCCONNELL 1992, 1)

The tradition of establishing *gewatta* can be found all over Sri Lanka, as they are an essential part of the agricultural system. In the following paragraphs the description of the *gewatta* system will be confined to the central highlands, *kanda udarata*, of the island, where the luxuriant system of Kandyan *gewattas* is widely spread and forms an essential component of land use. Most of the *gewattas* are found in sheltered valleys, adjacent to the paddy land and along slopes throughout the area.

After the decline of natural forests these diverse gardens are the last remnants of biodiversity, the last refuge for the island`s diminishing wild flora and fauna. Within the landscape they sustain soil cover and fertility and their contribution to microclimate and hydrology cannot be underestimated. Nevertheless the *gewatta* system is endangered today because the extensive and "unorganized" way of cultivation does not bring rapid and high monetary rewards for the farmer. As lifestyles and demands are changing, traditional methods of agriculture can hardly withstand modern trends. Improvements and intensification of the ancient and „archaic" *gewatta* system is proposed by many different authorities.

"Improvement without considerations of ecological principles underlying the maintenance of the system (features of diversity, layered vegetation, recycling system) as well as economic and socio-cultural factores, may entail its disappearance" (BOMPARD et al., 1980)

Therefore we decided to focus our research on the above mentioned principles: The diversity, structural features, nutrient cycle as well as the economic and socio-cultural features of the *gewatta* system.

3.4.2. Description of the *Gewatta* System

Entering a garden one has to follow the road along the paddy fields which fill the valley bottom with their terraces. Adjacent to the valley floor the steeper slopes are covered by the *gewatta* system, forming a green forest-like belt above the paddy fields. Runoff will be captured in those paddy fields, thus contributing to the fertility and minimizing the nutrient loss.

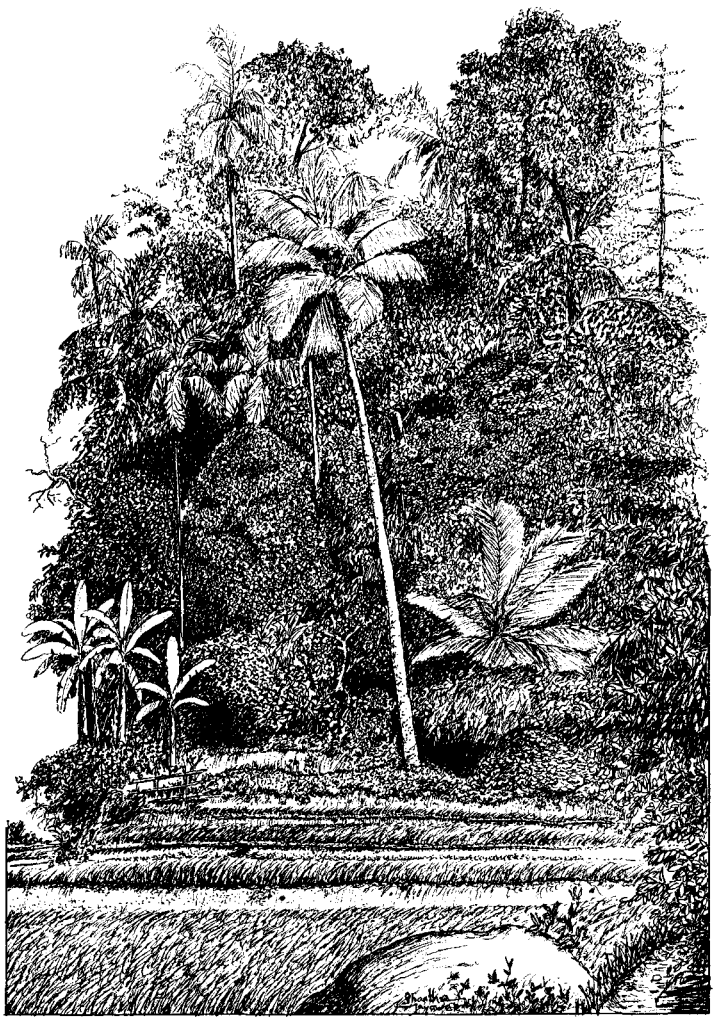


Figure 3.3. The *gewatta* form a green forest-like belt above the paddy fields

In our investigations all of the surveyed gardens were found on slopes between 5% to 30%. To cover a families' requirements of food, paddy field and *gewatta* are supplementary elements. Nowadays only a small percentage of the garden owners continue the cultivation of paddy. Their fields are sold or farmed out. From 158 families an estimated percentage of 20% to 30% were still carrying on paddy cultivation.

Usually a small pathway leads from the paddy fields to the garden. Sometimes the borders are marked with dense and fence-like growing trees or bushes. The garden is rarely bordered by a fence but the territory is generally acknowledged by neighbours and visitors.

The pathway to the house and the yard are carefully swept and free of vegetation which has many functional advantages. The place can be used to dry seeds and grains including rice and harvested herbs. In fact there is rarely a time of the year when someone enters the yard without seeing mats spread on the ground where seeds or grains are dried in the sun.

Around the yard ornamental plants are grown and depending on the inhabitants the place is nicely arranged or rather neglected. Near the kitchen we find some typical plants. Papaya (*Carica papaya*), curry pincha (*Murraya koenigi*) sometimes *Citrus* species which are said to keep insects away from the house as well as some fruit trees like guava (*Psidium guajava*), *Annona* species, uguressa (*Flacourtia inermis*). Here we will also find some light-demanding herbs used for cooking, chillie, rampe (*Pandanus sp.*) and tumeric (*Curcuma longa*).

Close to the main building there is a small outhouse and in the most distant corner there will be a well. The well and a small compound around is usually constructed of stones and cement. Some special ferns growing on the walls of the well are said to keep the water clean. Water is of vital importance to the villagers whether it is ground water, or a small river. Bathing and laundering of clothes consumes a lot of time. None of the objects we researched had sanitary equipment or any canalisation in the western sense.

The remaining part of the garden is not carefully organized or planted and has a wild and forest-like character. Trees and shrubs occur randomly, unevenly distributed and of different age. Climbers using support trees to stretch their veins towards the light are abundantly distributed throughout the garden. The high crowns of the trees shade the area. Small patches of sunlight on the ground will occur here and there.

The undergrowth is highly heterogeneous depending on light, microclimate and management. A layer of litter covers the ground. Ferns, grasses and different tree seedlings occur randomly. Where patches of light due to openings in the canopy occur, the vegetation of the undergrowth will be richer. Grasses and herbs can then build a thick vegetation cover.

Usually there are small footpaths leading through the garden but that is all one can see of human intervention. The litter-layer is swept in some places but most of the

undergrowth is not managed. People rarely spend their time in this part of the garden. They only go there to collect firewood or fruits.

Birds, small mammals, butterflies and other insects enliven the scenery. This part of the garden leads to the adjacent paddyfield or to another garden. The neighbouring garden is not clearly recognisable for a visitor but farmers themselves know the borders which are rarely marked. "This tree or those bushes" might be the farmer's answer asked for the border of his garden.

Some species are preferably used to mark the borders and to build up a fence-like hedge row: *Areca catechu, Manihot glaziovii, Bambus vulgaris, Erythrina variegata, Ceiba pentandra, Caryota urens, Thespesia populnea, Hibiscus rosa-sinensis* or *Polycias belforiana*. Fruit trees or species with valuable products rarely grow near the border. Fruit trees especially are mostly found close to the house.

The intensity of management decreases further away from the house. This trend can be observed in all *gewattas* of a certain size larger than 1000m². In our survey the mean average garden covered an area of 5250m² and it is remarkable that the set up of the *gewatta* with the characteristics described above did not vary with the size.

3.5. The Floristic Composition of the *Gewatta* System

3.5.1. Introduction

> *Every peasant's plot was set so thick with jak and bread fruit trees and coconut palms that it seemed as though nothing else could grow there; yet where there was space in the yard, vegetables were grown, and flowers also found a place.* Martin Wickramasinghe, Ape Gama

The tropical regions with their favourable climatic conditions are said to be extremely rich in species and to have a high occurrence and grouping of the elements of most of the typical tropical vegetation types. Traditional farming systems and „ancient" practices of agriculture manifest that diversity. Sri Lanka, because of its geographical position and its physical features, has a relatively wide range of climatic regions and a correspondingly rich and varied flora. This flora remained more or less undisturbed by man up to 500 B.C. From then onward various crop plants such as rice, millet, sugar-cane and sesame, along with tamarind, jak, and many other trees, together with other forms of settled agriculture were introduced to the island from the Indian sub-continent (ABEYWICKREMA).

The composition of plant species found in the *gewatta* system reveals various origins. More than 2000 years of agricultural activities have led to a selection of many useful trees, shrubs and herbs which can be grown close to human settlements. We can assume that the earlier settlers and farmers collected fruits, nuts and resins in the forest. In fact most of the plants might have germinated on their own after seeds were thrown away as kitchen waste. If a new plant germinated near their hut they might have watched it curiously eventually recognising what kind of tree was growing there. Neighbours might have exchanged useful species, traders brought new varieties and slowly the immense diversity of useful species found in the *gewatta* today evolved out of trial and error.

The historical book *Mahavansa* records some interesting facts about the ancient *gewattas* of Sri Lanka before the 4th century. According to a recent study (Wijesundera, oral communication), an ancient homegarden was dominated by the following plant species: Mango (*Mangifera indica*), jak (*Artocarpus heterophyllus*), bread fruit (*Artocarpus sp.*), banana (*Musa spp.*), bulu (*Terminalia belerica*), *Phyllanthus emblica*, coconut (*Cocos nucifera*), palmyra palm (*Borassus flabellifer*), *Michelia champaca*, *Mesua sp.*, *Mallotus phillipensis*, *Couroupitya guianensis*, *Stereospermum suaveolens*, *Nauclea orientalis*, *Mimusops elengi*, *Garcinia sp.*, *Wrightia antidysenterica*, jasmine (*Jasminum sp.*) and probably *Madhuca longifolia*. The basic needs of the ancient Sinhalese could be sustained with paddy fields, *chena* cultivation and *gewatta*.

At the beginning of the 16th century the Portuguese, Dutch and British introduced new species which adapted to the suitable climate on the island: Cloves (*Syzygium*

aromaticum), nutmeg (*Myristica fragans*), tea (*Camellia sinensis*), coffee (*Coffea arabica*), rubber (*Hevea brasiliensis*), cocoa (*Theobroma cacao*),and papaya (*Carica papaya*) to name some. Since then the cultivation of so called cash crops has expanded and today many of the plants commonly found in the gardens are not indigenous to Sri Lanka.

Speaking to some old villagers we learned that the structure of settlements had changed during the last 100 years. Earlier, houses were built closer together and were not scattered as today, because people had had to protect themselves and their livestock from wild animals. Therefore there had not been enough space to cultivate big trees like jak (*Artocarpus heterophyllus*), breadfruit (*Artocarpus altilis*) or coconut (*Cocos nucifera*). Betel nut palm (*Areca catechu*) however, was very common in those days. From these descriptions we become aware that the composition of species has changed throughout history with the changing requirements of people.

Another important factor that changed the importance of *gewattas* was the restriction of *chena* land (land for shifting cultivation). Vegetables, leguminous plants and grains were grown on *chena* lands and supplied people with means of subsistence. In the year 1823 the first plantation of coffee was established, followed by tea, rubber and coconut. During that time vast areas of forest had to be cleared and no more space for *chena* land remained. Since then *chena* cultivation has disappeared from the west-coast and almost completely from the entire highland, whereas the *gewatta* system has grown in its importance for subsistence production.

Today the areas under natural forest are still declining and the *gewatta* system has adopted a new task, namely in providing refuge for native species. In fact, this role may become more important in the future. Though the gardens are individually managed, the structural effect of several neighbouring gardens is often similar to that of a small forest. The typical species composition in a traditional *gewatta* shows high diversity. Trees, shrubs, vines and herbs grow together in an irregular and somewhat disorganised manner. Because of the predominance of perennial species, a *gewatta* has the appearance of a forest. Structural and functional characteristics can thus be seen as similar to the local natural forest.

3.5.2. Taxonomic Composition of the *Gewatta* System

If one takes a closer look at the composition of plant species of a *gewatta* system some classifications can be made. A total of 640 species were identified in the 158 surveyed *gewattas* in the Central Province of Sri Lanka. Species richness varied from 22 to 170 species of trees, shrubs and herbs for one garden with a mean of 53 species[1].

Not all species occur with the same frequency and species composition may vary in different regions. Out of 640 species 480 more common species were determined and

[1] Ornamental plants close to the house are not included in this data.

a total of 105 families were identified. The complete floristic list is given in the appendix

The *Leguminosae* were the most important family with a total of 42 species found in all structural layers of the gardens. These were followed by the *Euphorbiaceae* with 32 species, the *Rubiaceae* with 15 species, the *Verbenaceae* with 11, the *Apocynaceae* with 10 species and *Sapindaceae* with 9 species.

The most important and dominant plant families and species are listed below.

Family	Species
Leguminosae	42
Euphorbiaceae	32
Rubiaceae	15
Verbenaceae	11
Apocanaceae	10
Sapindaceae	9

The remaining families were confined to a special layer of the garden. The following list names plant families and species arranged according to life forms and structural layers.

Trees	Sp.	Shrubs	Sp.	Climbers	Sp.	Herbs	Sp.
Myrtaceae	13	*Rutaceae*	21	*Menispermaceae*	7	*Compositae*	20
Moraceae	12			*Convolvulaceae*	6	*Gramineae*	19
Anacardiaceae	9			*Piperaceae*	6	*Cucurbitaceae*	10
Palmae	8			*Dioscoreaceae*	4	*Solanaceae*	10
Guttiferae	7					*Araceae*	10
Meliaceae	7					*Labiatae*	9
Lauraceae	6					*Malvaceae*	9
						Amaranthaceae	9

Observing the structural characteristics of the *gewatta* system one can distinguish three to four or even five main layers or niches. In order to create a general view of the species compilation in a *gewatta* system we decided to divide the vegetation into four different categories according to their structural characteristics. Trees, shrubs, climbers and herbs form the main structural components of the system. The next section will be confined only to the most common species of trees, shrubs, vines and herbs found in all areas investigated. The particular distinctions between the different areas will be elaborated in the next chapter.

3.5.3. Trees

The tree-layer is formed by woody species growing taller than 10m and up to 35m, which is the canopy level of a garden. Three different categories of trees can be defined; emergents, canopy and sub-canopy. Henceforth we will refer to all these species as „trees", including the family of *Palmae*.

The first impression gained of a traditional homegarden is that of its dense and forest-like character. If one looks closer, different species can be distinguished. Jak (*Artocarpus heterophyllus* Sinh.: kos) and coconut (*Cocos nucifera* Sinh.:pol) dominate the canopy with their expanding crowns, areaca palm (*Areac catechu* Sinh.:puak) is also commonly found but the rather small crowns do not dominate the canopy layer. Apart from jak and coconut many other tree species occur in different layers of the garden. Mango (*Mangifera indica* Sinh.:amba), fishtailpalm (*Caryota urens* Sinh.:kitul), avocado (Persea americana Sinh:.aligeta pera), cloves (*Syzygium aromaticum* Sinh.:carabu), gliricidia (*Gliricidia sepium* Sinh.:wetaini), *Macaranga peltata* (Sinh.: kenda) and breadfruit (*Artocarpus altilis* Sinh.:del) can be found in a common homegarden of the wet and intermediate zone. A complete list would fill many pages, a total of 206 different tree species were recorded in the 158 *gewatta*s surveyed. This diversity is remarkable and provides a rich natural resource for the country.

The majority of species are planted to provide their owners with one or more useful products. However, endemic and naturalized trees make up a considerable proportion of the garden. Some of them are of great utility to the farm family such as jak (*Artocarpus heterophyllus*) which is generally planted, others are self seeding or dispersed by animals such as the kitul tree (*Caryota urens*). Around 30% of the tree species documented were never planted. Sometimes birds, small mammals or bats spread them and, should the seed find space and a suitable environment, it grows. Later on it may be suppressed by other, bigger trees, or perhaps animals eat the young sprout, or the farmer decides to cut it. Therefore many of the trees grow as they would in a natural forest, with no obvious planning, randomly placed and unevenly aged. People know each species and have some use for almost all of them. Not all species occur with the same frequency and different categories of trees can be distinguished.

The variation in the composition of tree species is dependent on the geographic area and the neighbouring vegetation as well as on the farmers` preferences. In general the most frequent species were the 6 listed below, which are multipurpose species with a high number of useful by-products. They can be found in nearly every garden and therefore these trees can be called the "core species of the *gewatta* system".

Common tree species and their uses in percentage of occurrence

species	in %	way of cultivation	different uses
Artocarpus heterophyllus	88%	wild germination, seeds	food, timber, fuel wood, fodder, dyes, medicine, ornaments, toys, latex, cultural importance,
Cocos nucifera	84%	seeds	food, beverages, medicine, oil, fuel wood, timber, fibres, ropes, religious and cultural importance, fodder, wrapping, baskets, mats, packaging, thatching, handicrafts light industries, utensils, equipment, floats, mechanical support for climbers,
Mangifera indica	79%	seeds	food, timber, fuel wood, medicine, cultural importance
Areca catechu	79%	wild germination	timber, fuel wood, medicine, stimulant, religious and cultural importance, tools, kitchen utensils, brooms, decorations, wrapping, erosion control, fencing, mechanical support for climbers
Caryota urens°	72%	wild germination	beverages, food, flavouring agent, fibre, fodder, timber ornamental plant, medicine, handicrafts, broom tools, brushes, fencing
Gliricidia sepium	72%	cuttings	fodder, fuel wood, fencing, compost, soil conservation, mechanical support for climbers, shade

° indigenous to Sri Lanka

When grown in their suitable environment *Artocarpus heterophyllus* and *Cocos nucifera* are part of every traditional homegarden. They dominate the floristic composition and are important for the structural components of a garden. Both trees bear fruit throughout the year and in folklore and superstition they are regarded as "lucky trees", bringing luck and prosperity to the house.

Jak Tree, *Artocarpus heterophyllus*
Moraceae

The tree originates in India and is today cultivated all over South Asia. The impressive large fruits hang on short thick stalks from the trunk or large branches. Each fruit contains many kidney-shaped seeds with a thin white coriaceus testa, ripened seeds have a distinctive pungent odour but are edible.

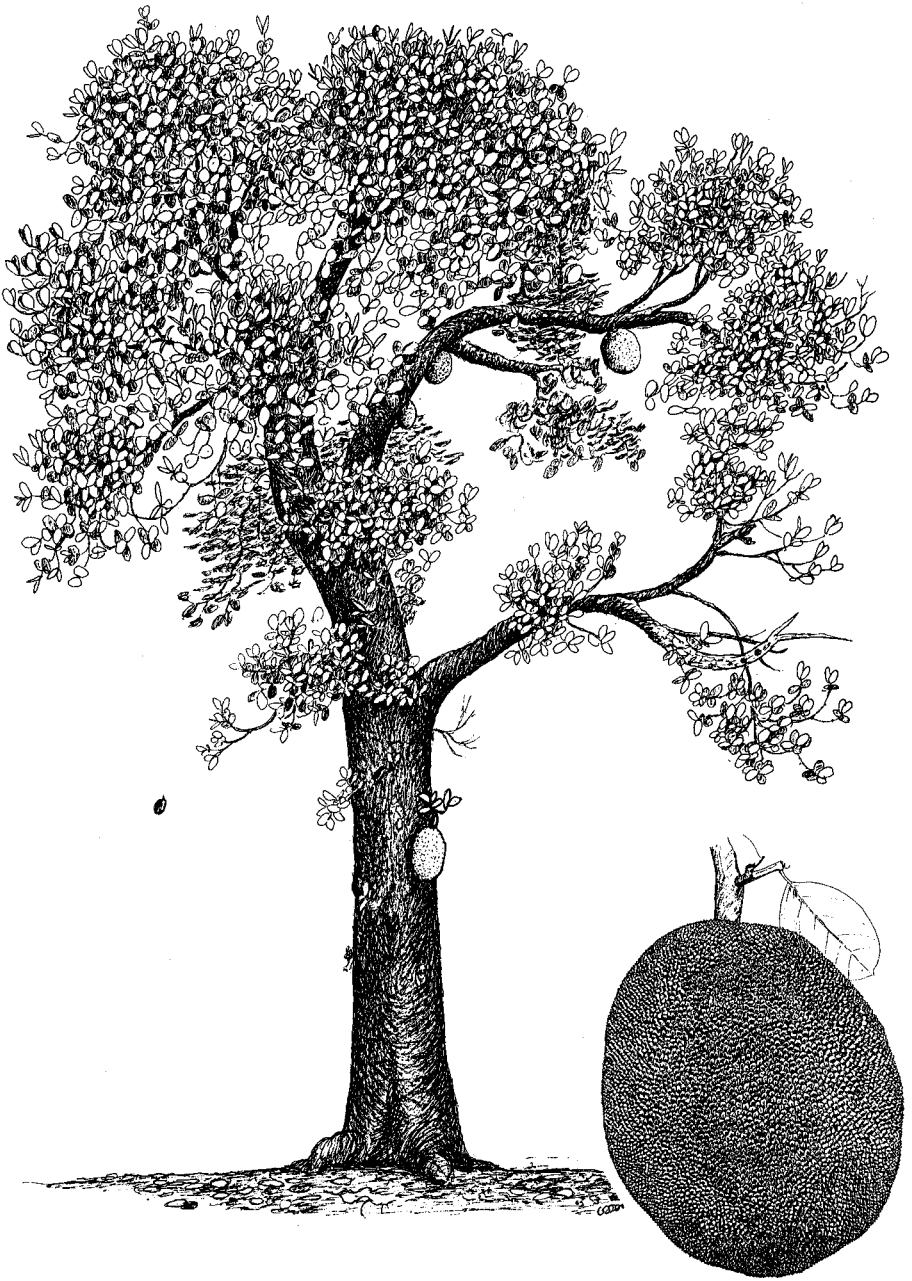


Figure 3.4. Jak tree and jakfruit

The jakfruit is rich in carbohydrates and can substitute rice in a meal. A single fruit is equivalent to one measure of rice and is adequate for a family of three or four persons as a single meal. The jakfruit can be cooked at all stages, it can be eaten raw when ripe and prepared as curry when unripe. The different names given to the fruit at different stages of ripening like "Getakos", "Polos", "Dandukos", or "Waraka" also refer to different methods of preparation. The seeds of the ripe fruit contain a high percentage of starch. Roasted, boiled or ground are the most common methods of cooking.

The jak tree has always played an important part in daily life. In ancient times monk`s robes were coloured from dyes produced from its saw dust and roots which gave a rich golden hue to the fabric.

Valuable timber used to make furniture is provided by the tree. It is as strong as teak and takes a good polish, saws and works easily and is durable under water. The firewood has a high calorific value. The leaves are lopped for fodder, ripe fruits can be fed to cattle, elephants eat the bark in addition to its leaves and fruits. The milky exudation resulting from tapping the tree is another useful by-product.

The tree is easy to maintain and its seeds germinate readily. There are two varieties, "Waraka" and "Wela", which are said to differ in their taste. During our observations the jak tree bore fruits in the months from January to April, flowers and flower buds were seen from December to March.

Coconut, ***Cocos nucifera***
Arecaceae

The tree originates in the Melanesian region, which is still the main area of cultivation. The earliest descriptions are transmitted from Sanskrit, from around 1000 B.C. In Europe the name "coco" first appeared in the 16th century in letters and descriptions of Portuguese and Spanish sailors. The tree belongs to the most beautiful palms of the tropics. It can reach an age of 100 years and a height of 30m. The main trunk is unbranched with a thick swollen base surrounded by a mass of adventitious roots.

The fruit needs 12-14 months to mature, 50-80 fruits per year can be yielded from an average tree aged between 12 and 40 years. The coconut tree is called the `tree of life` owing to its manifold benefits. In India the tree is sacred and the fruits are used on many occasions of worship, especially in marriage ceremonies. In Sri Lanka the fruit is a major ingredient of Sinhalese meals. The traditional curries prepared all over the island are cooked with coconut milk and the daily consumption observed throughout the survey is about one nut per day and family. Moreover the tree provides fuel by way of its coconut shells and its leaves are suitable to light a fire. The tree trunk is used as timber for house construction, the coconut shells are used as fuel and as domestic utensils such as drinking vessels, toys, musical instruments and other tools. The leaves can be plaited and used for thatching, wrapping materials, mats, and as decoration for cultural events. Fibre, strings and ropes are another important by-product. The oil has a wide application in the manufacture of cosmetics such as shampoos and creams. A

delicious beverage is derived from a special variety, the king coconut. The palm sap can also be used to prepare an alcoholic drink, arrack.

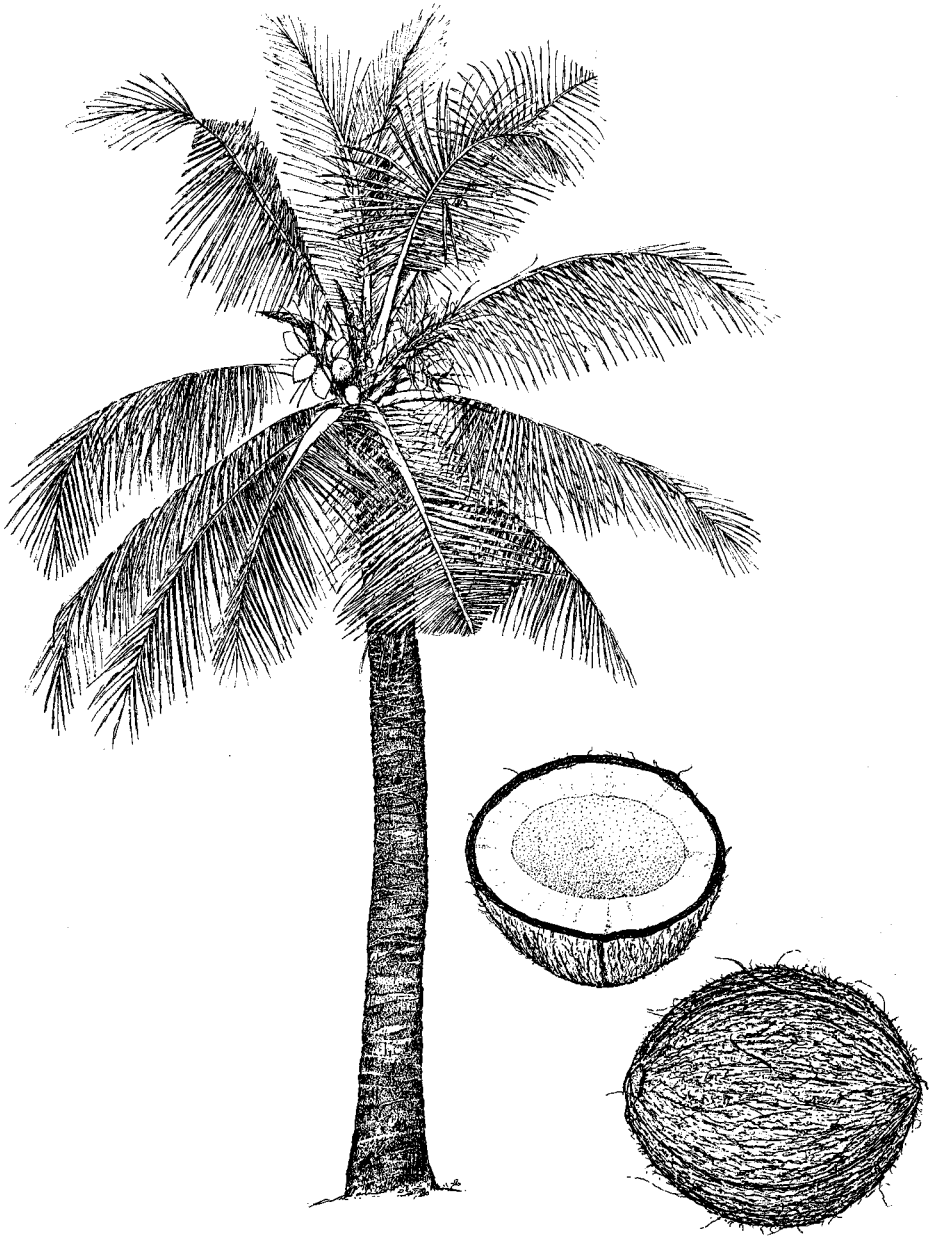


Figure 3.5 Coconut palm and its fruits

The tree is also of medicinal value. The soft substance found on the lower part of the leaves is used as a styptic for stopping bleeding, ist flowers are said to be astringent, the root is regarded as a valuable diuretic, the water or milk is prescribed for fever and its blood purifying qualities.

Many statistics list the coconut palm merely as the source of copra for producing oil. But that categorization is too simple, the coconut is an integrated component of the rural culture in many parts of the tropics today. The number of useful products and by-products is enormous and there is a great amount of knowledge involved in growing, using and processing coconuts.

The tree has to be planted and watered during the first months, germination is slow and it takes about 4 months for the shoot to emerge. It is not easy to maintain and is susceptible to pests and diseases. In our survey we found the palm growing in areas up to an elevation of 900 m. In our observations the tree was flowering and bearing fruit throughout the year though a peak could be noticed in April.

Mango, *Mangifera indica*
Anacardiaceae

The mango is found wild or semi-wild almost throughout India, from there it was brought to Arabia and Africa in the first millennium A.D. and is now the most important tropical fruit after the banana. The mango is a large tree with expanding crown and thick, rough grey bark. Leaves emit a resinous odour when crushed. In Sri Lanka a great number of different varieties of mangos exist, fruits can be large, green, yellowish or red, often dotted and of different shapes. The tree is mostly grown from seed.

The tree can be used as timber, being soft, easy to saw and machine. It is widely used because of its easy availability and cheapness. Furniture, floor and ceiling boards or door and window frames are often made of mango wood. The calorific value of mango wood is high. The bark contains tannin and is used for tanning purposes. The fresh bark and the flowers have some medical value and are used in the treatment of diarrhoea, dysentery and scabies. Leaves are used for decorations and as a good omen in social functions. Ripe und unripe fruits can be prepared into chutneys and pickles, jams, jellies and syrups and have a high potential for local food processing industries. The mango tree is regarded as being sacred, especially in the Hindu religion, and the leaves are used in many ceremonies. Our phenological observations showed that the mango flowers irregularly, depending on region and variety, while leaves are renewed all year round. New leaves appear at the end of branches and are pink or reddish in colour.

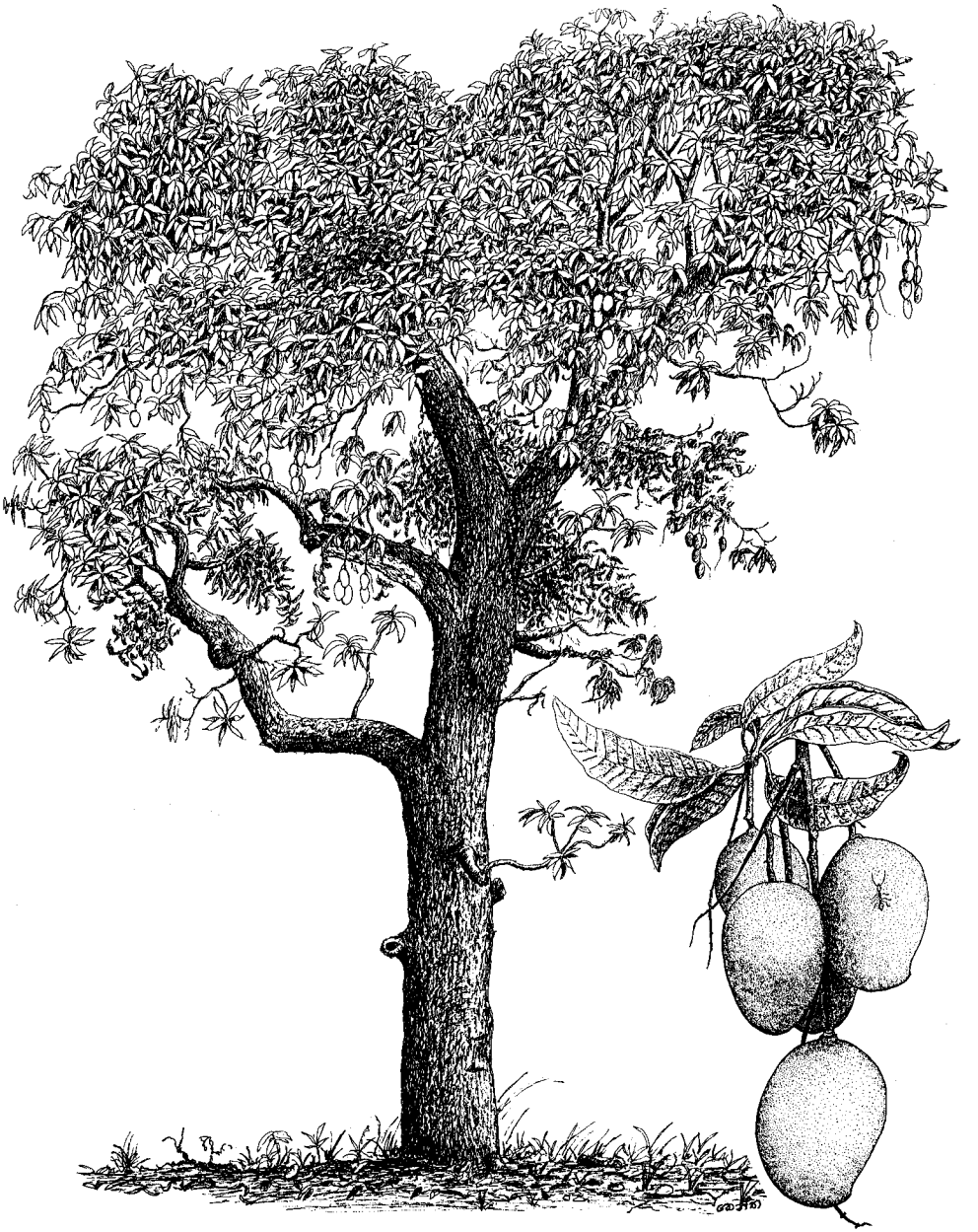


Figure 3.6. Mango tree and its fruits

Areca Nut or Betel Nut Palm, *Areca catechu*
Arecoidae

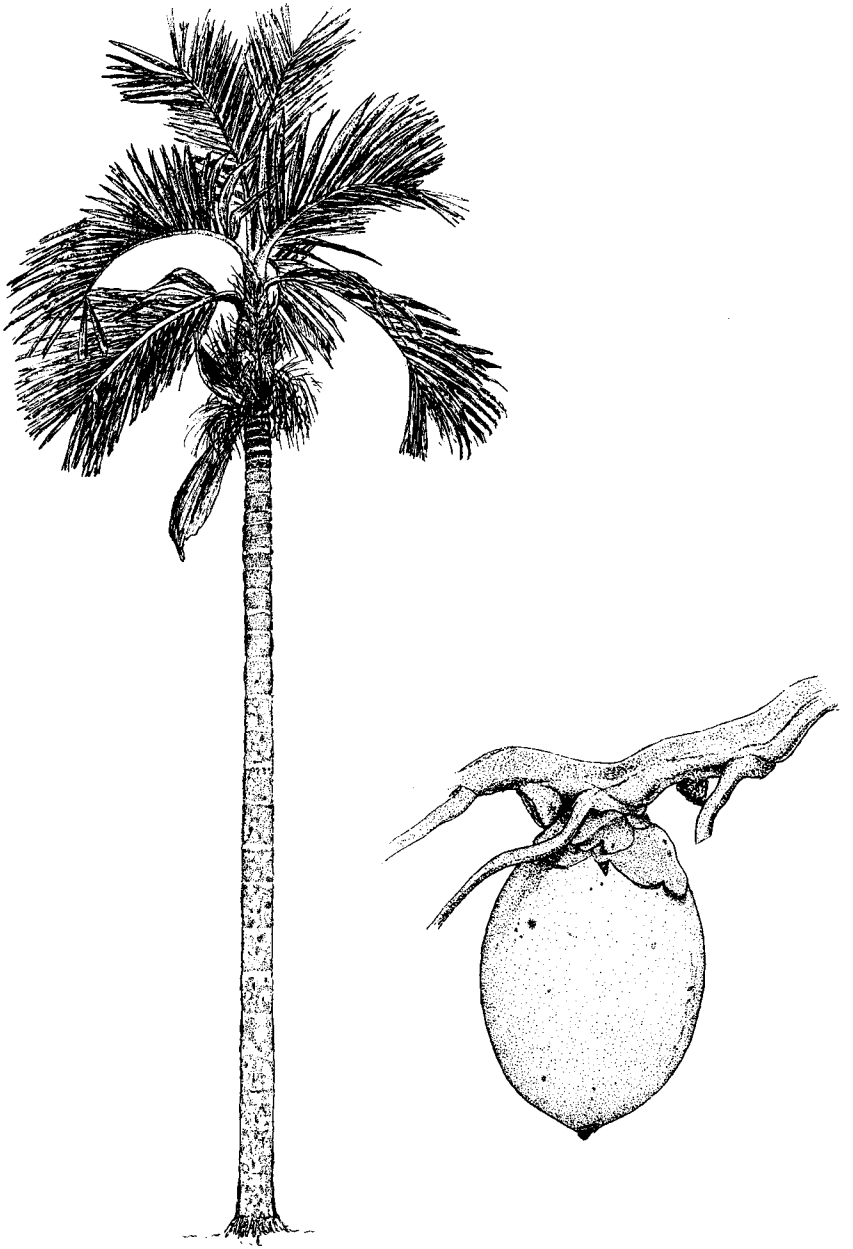


Figure 3.7. Betel nut palm and betel nut

The betel nut palm was introduced to Sri Lanka and has been of cultural importance for probably more than 2000 years. The nuts were used as a means of barter in ancient times. The nut is still exported to India. The nut, chewed together with the betel leaf (*Piper betle)*, as well as burnt lime and tobacco, has a stimulating effect. Burnt lime tranforms the alkaline Arecolin into Arecaidin, which can be called "the poor man`s drug", diminishing hunger and tiredness (RAGHAVAN, BARUAH 1958). The plant is part of many cultural and religious ceremonies in India and Sri Lanka. In remote villages the custom of offering these chewing ingredients to any visitor and neighbour while having a chat in the shade of the porch still exists. Besides the nut, the tree provides timber and fuel. The betel nut also acts as a medicinal drug and as a dye or tannin. The tree is useful as fencing and for erosion control because it can be grown to form a narrow belt.

Fishtail Palm, *Caryota urens*
Arecoidae

The fishtail palm, called *kitul* in Sri Lanka, is native to topical Asia. The palm is tall (up to 20m) and inhabits the understory tree stratum in moist lowland and submontane forest. In Sri Lanka its distribution was found to be less than two trees per ha, indicating its rarity in the wild. The palm is more common around village homegardens. The palm sap of this plant is used to produce palm syrup, jaggery (a crude brown sugar) and treacle *kitul penny.* Both are traditional sweeteners and they are very popular in Sri Lanka. "At the village level it is of economic importance, especially for communities living along forest fringes, providing a significant source of income to the people." (DE ZOYSA 1992, 28).

The sugar sap can also be converted into a weak alcoholic beverage (*toddy*), when the nectar is allowed to ferment. The procedure of sapping the flower is difficult and involves appropriate knowledge and skill such as the ability to recognise the right time to cut the flower, and the preparation of a special mixture of medicine in order to increase the flow. The exact recipe is the individual tapper´s secret. The tapping of the tree is mainly a task for men whereas women filter the sap and boil down the syrup to prepare jaggery. These practices will only be found in remote villages where jaggery forms a major source of the surplus income. Areas close to the lowland rainforest Sinharaja are especially famous for this traditional custom. Close to towns these practices are vanishing. The syrup plays a special role in certain rites and is commonly offered at the temple.

Besides the *kitul penny* the palm provides timber, fuel, leaves for thatching the roof and fodder, which was mainly used for elephants in ancient days. The wood is dense and hard, making excellent tool handles, ploughs, and mortars for pounding rice and structures such as bridges. When a *kitul* was cut we noticed that farmers waited until the inner, watery part of the palm rots. By the sound the trunk made when kicked they were able to decide for which use the tree was ready. The inner part of the trunk can be processed to make a kind of flour which is mixed with kitul penny and makes delicious sweetmeats.

Figure 3.8. Kitul palm and traditional tapping instruments

Within a *gewatta* the palm is never planted but mostly dispersed with the droppings of the Common Indian Palm cat (*Poradoxurus hermaphroditus*) or by fruit bats. "Whether any specialized relationships exist between the palm and its dispersal agents is not known." (DE ZOYSA 1992, 30) Due to an increasing demand for kitul products the process of natural regeneration is already severely affected. The popularization of the *kitul* palm for the *gewatta* system should therefore be vigorously pursued.

Areca nut and kitul palm represent typical traditional species in Sri Lanka, which have been passed down from ancient times from one generation to the next. Both are intensively connected to cultural practices. Their maintainance is easy and needs no effort, yet their use and adaptation is attached to considerable knowledge and skill.

Gliricidia sepium
Leguminosae

Gliricidia sepium together with pepper (*Piper nigrum*) represent the cash crop component of the *gewatta* system. *Gliricidia sepium* is in most cases used as a support plant for pepper vines. *Gliricidia* is a fast growing species, the tree being rather small reaching up to 10m. It has an open crown and contorted trunk. The tree was naturalized in many parts of the tropics and is easily propagated by cuttings. The wood can be used as timber and fuel. The long leaf branches make it ideal as a shade-, support- or fence-tree. The green foliage can be used as fodder or as green manure as it is rich in protein. The tree is suitable for degraded sites because it fixes nitrogen by way of its root nodules. We observed flowers from March to April and leaves sprouting from November to December and again from April to August.

Maintaining and growing trees within the limited area of an average garden (2000 to 5000m²) the farm family has to make some decisions regarding tree products and species. The combination of different qualities in one tree (multipurpose tree) seems to play a major role in the preferred selection of the farmer. The tree should provide the family with multiple products and should be easy to maintain. Products and maintenance are equally important. Especially for women the multiple use of trees is desirable. Trees producing fruits/food and firewood within close access to the kitchen and requiring minimum maintenance have priority in the selection process.

Income from surplus production can be another motivation to grow a tree. Some trees provide food, fruits and other important by-products for the family from which the surplus production can be sold at the local market. Another group of trees, such as clove or nutmeg, provide products for the export market and low benefit for the farm family. They form the so called cash crop component of the *gewatta* system.

The following list names some tree species which are planted and maintained or just tolerated because of their usefulness. They provide a great number of different products for daily life in a village.

Table 3.2 Less common tree species in percentage of occurrence

species	in %	way of cultivation	different uses
Persea americana	69%	seeds	food, market product, medicine
Syzygium aromaticum	65%	seedlings	export crop, medicine, flavouring agent
Macaranga peltata°	50%	wild germination	wrapping, medicine, pioneer plant
Artocarpus altilis	44%	root suckers	food, wrapping, timber, fuel wood
Michelia campaca	43%	wild germination	timber, fuel wood

° Introduced species

Avocado, *Persea americana*
Lauraceae
The avocado originates from Central America and has been cultivated all over the tropics since the beginning of this century. The fruit has a high nutritional value because of its protein and oil content. For local sale the fruits are picked when they are beginning to soften. Avocado may be propagated from seed or grafts.

Clove, *Syzygium aromaticum*
Myrtaceae
The clove tree can reach a height of 20m and has a dense and conical crown. The young flower buds of this tree are used as spices. The clove tree is an export crop and in Sri Lanka the cultivation is confined to the wet zone. Cloves have some medicinal value but mostly they are grown for surplus cash income. In order to produce good quality results, harvesting and drying need some skills and the plant must be fertilized regularly.

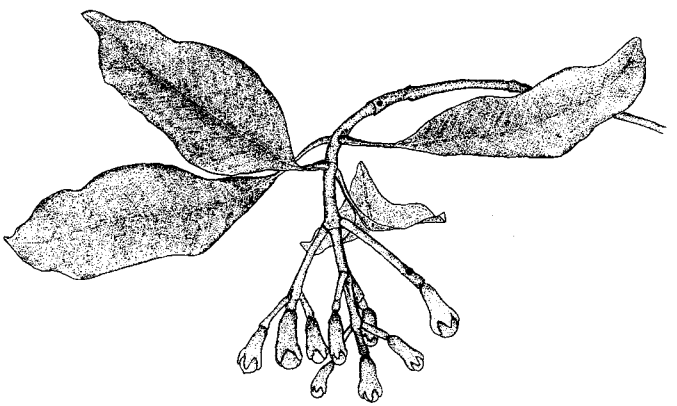


Figure 3.9. Flower buds of the clove tree

The plant is propagated by seeds and is not easy to maintain, being more susceptible to pests and diseases. The tree requires light and is therefore sometimes difficult to grow within the *gewatta* system. Phenological observations showed that the tree flowers from August to December, while harvesting was mostly done in January. Leaves are renewed from April to July.

Macaranga peltata
Euphorbiaceae
The tree is a typical fast-growing and light-demanding pioneer species. The leaves are used for wrapping and to prepare a special sweet dish, furthermore it provides a medicinal drug, gums and timber. The tree is tolerated but never planted purposely. It highlights the natural character of the *gewatta* system with gaps and disturbances caused by human impact.

Michelia campaca
Magnoliaceae
The tree is mainly used as timber and fuel wood, it can also provide medicinal drugs, perfume and essential oils as well as dye and tannin. We observed leaves sprouting from March to July and again from October to December.

Breadfruit Tree, *Artocarpus altilis*
Moraceae
The tree originated from the Malayan Archipelago where it has been cultivated since antiquity. The breadfruit is a close relative of the jak tree but is not as widespread in Sri Lanka. The breadfruit is a starchy food, a single fruit providing 2700 calories, the minimum requirement of a field worker. However it lacks protein and thus a diet is incomplete unless supplemented with other sources. The fruit can be cooked like potatoes, fried, boiled or baked. The tree is mostly grown from root suckers and requires little care in propagating.

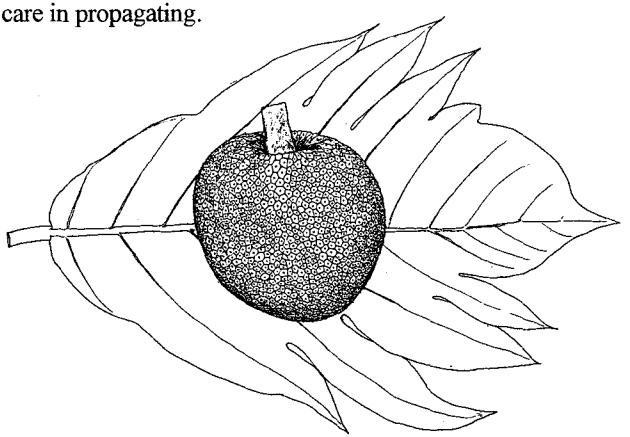


Figure 3.10. Breadfruit

Figure 3.11 Breadfruit tree

Less common tree species

In order to categorize the remaining trees found more or less commonly in the *gewatta* system we identified different groups. These groups of tree species form the main functional basis of a *gewatta* system. The following list will give some examples of the more common species ranked by frequency of occurrence:

- **Self germinating species of multipurpose use**

Most of these species produce some by-products useful for the villagers. *Ceiba pentandra* for instance has cotton like fruits which are used to stuff pillows or mattresses. Some trees deliver valuable medicinal products like *Azadiracta indica* or the Neem tree which is today regarded as a potential natural pesticide. *Adenanthera pavonia* is likewise a valuable medicinal species found in many traditional recipes. A high percentage of the self-germinating species come from the forest and are part of the indigenous flora. Therefore these species depend for their distribution on the neighbouring environment and the ecological situation of the garden.

Some rare tree species of this group are listed below:

rare species	uses	
Corypha umbraculifera	thatching, cultural, and religious importance, umbrellas, handicrafts	7%
Alstonia scholaris	timber, fuel wood, medicine, coffins, toys	7%
Semecarpus nigroviridis *	timber, fuel wood, medicine	7%
Acronychia pedunculata	pioneer plant, shade tree, medicine	6%
Litsea glutinosa	medicine	6%
Albizia odoratissima	timber, fuel wood, erosion control, shade tree	6%
Artocarpus nobilis *	starch, edible fruit and seeds, dyes and tannins	6%
Terminalia catappa	fire wood, shade tree, edible fruit,	6%
Canarium zeylanicum *	timber, medicine	5%
Carallia brachiata	timber, fuel wood	5%
Cassia fistula	medicine, edible fruit, ornamental plant, shade tree	5%
Nothopegia beddomei	fire wood, timber	5%
Trema orientale	the tree attracts many bird species	5%
Syzygium cumini *	timber, shade tree, edible fruit	5%
Cycas circinalis	medicine, ornamental value, starch plant (stem)	4%
Careya arborea	medicine, food	3%
Schumacheria castaneifolia *		2%
Vateriea copallifera	timber, starch, dyes and tannins, cements and resins	1%

*Endemic species

The following list shows very common and less common species of this group in percentage of occurrence:

very common	in %	uses	less common	uses	in %
Michelia champaca	43%	timber, fuel wood, oil, dyes, tannins	*Phyllanthus indicus*	timber, fuel wood	12%
Neolitsea cassia	37%	timber, fuel wood, food ingredient	*Ficus hispida*	medicine, sandpaper	11%
Alstonia macrophylla	31%	timber, fuel wood, erosion control	*Filicium decipiens*	fuel wood, ornamental value	11%
Swietenia macrophylla	27%	timber	*Alophyllus cobbe*	medicine	11%
Ceiba pentandra	26%	coffins, material for pillows, fencing	*Albizia lebbeck*	timber, erosion control, firewood	9%
Melia dubia	21%	timber, fuel wood	*Oroxylum indicum*	medicine, toys	9%
Bambusa vulgaris	19%	timber, handicrafts, toys, cages, fencing, ornamental value	*Erythrina variegata*	soil conservation, firewood, fodder, fencing, compost	9%
Thespesia populnea	17%	fencing, soil conservation	*Vitex altissima*	timber	9%
Leucaena leucocephala	17%	fuel wood, fodder, fencing, compost soil conservation	*Berrya cordifolia*	timber, fuel wood	9%
Adenanthera pavonina	16%	medicine, toys	*Ficus religiosa*	religious, cultural importance	9%
Cananga odorata	15%	timber, fuel wood, oil, perfume	*Vitex negundo*	medicine, hedge plant, religious importance	8%
Tectona grandis	13%	timber			
Azadirachta indica	13%	medicine, timber, insect repellent, religious importance,			

- **Planted and maintained species with multiple uses, mainly food, firewood and flavouring agent**

Some of these have specified functions such as fencing, ornamental value or the production of special goods. These species contribute to the subsistance production of the family and are therefore highly dependent on the area and the socioeconomic set up of the village.

Very common and less common species of this group are listed below:

very common	in%	uses	less common	in%	uses
Nephelium lappaceum°	36%	fruit	*Anacardium occidentale*°	9%	nuts, fruit, oil, timber, adhesive, medicine
Myristica fragrans°	31%	medicine, export crop, spice	*Manihot glaziovii*°	9%	fencing, soil conservation
Durio zibethinus°	25%	fruit, timber, fuel wood	*Cedrella toona*	8%	timber
Syzygium jambus	24%	fruit, medicine, shade tree	*Grevillea robusta*°	8%	timber, fuel wood, erosion control, shade tree
Cinnamomum zeylanicum	23%	spice, medicine, export crop	*Spondias pinnata*	8%	edible fruit and seeds leaves supply amara gum
Tamarindus indica°	23%	food, medicine, timber, fire wood, spice	*Madhuca longifolia*	7%	oil, medicine, fuel wood, timber, soil improvement
Sesbania grandifolia°	18%	vegetable, medicine	*Phyllanthus emblica*	6%	edible fruit
Elaeocarpus serratus	18%	fruit, medicine	*Aegle marmelos*°	5%	fruit, beverages, latex, medicine, adhesive
Moringa oleifera°	16%	oil, vegetable, spice, medicine	*Feronia limonia*	3%	food, medicine, fuel wood
Averrhoa bilimbi°	13%	fruit, flavouring agent			
Garcinia quaesita	16%	fruit, flavouring agent, latex, medicine			
Garcinia mangostana	12%	fruit, medicine			
Hevea brasiliensis°	14%	timber, fuel wood, latex, toys, ornaments			

° Introduced species

3.5.4. Shrubs

The next group of woody plants and herbaceous perennials growing from 1m to 10m build the shrub layer of a typical *gewatta* system. A total of 153 species belonging to this layer were documented in the surveyed *gewattas*. Three different categories of shrubs can be identified.

- Species planted and maintained to produce fruits, food, spices, beverages or surplus income

They represent a group of plants on which human impact is clearly recognisable. Most of them require adequate sunlight and need some maintenance and care. They are mainly found close to the house. They would not occur in forests and without human maintenance they would not be able to compete with other species and would eventually vanish.

- Species with ornamental value cultivated for cultural or religious purposes

They show the cultural background of families and can be seen as an indicator of different customs.

- Species which represent the natural undergrowth of forest in the specific area.

They are propagated by wild germination only and are highly variable depending on regional environmental conditions as well as adjacent vegetation. Some of them are valuable medicinal plants.

- **Species planted and maintained mostly in close vicinity to the house producing fruits, food, spices, beverages or surplus income**

The following list names some examples of the more common species in percentage of occurence:

species	in %	cultivation	uses
Musa spp.°	84%	suckers from the parent plants	vegetable, fruit, fodder, wrapping, religious, cultural ceremonies, medicine, floats, fibre, whips
Carica papaya°	69%	propagation from seeds	fruit, latex, toys for children
Coffeae sp.°	69%	propagation from seeds	beverages, export product, medicine
Murraya koenigii	62%	vegetative propagation	flavouring agent, medicine
Manihot esculenta°	49%	propagation from cuttings	starch plant, toys for children
Citrus sp.°	47%	propagation from seeds	fruits, medicine, flavouring agent, market product

° Introduced species

Banana, Plantain, *Musa spp.*
Musaceae

The genus *Musa* includes 50-60 species which originate from Asia. The classification of a certain species in the genus is more than difficult as there are numerous hybrids. In Sri Lanka various forms of bananas with different genetic constitutions can be distinguished. Many of the plants found in the *gewatta* system bear small fruits with seeds. (REHM, ESPIG 1991)

The banana is a herbaceus perennial with an underground rhizome. Under favourable conditions the banana grows with surprising rapidity and the fruits are available all year round. The delicious fruit is popular and we can find a great number of different varieties all over the island. The ashplantain, for example, is mainly used for cooking. Another variety, with a delicate taste, is mainly used for offerings at the temple. Traditional varieties are excellent in taste but they cannot be transported over long distances. Therefore there are different traditional practices found to ripen the banana bunch when it is cut unripe. *Croton laxifera* is one example used for that purpose. In that way surplus production can be sold at the local market.

The banana flower is made into a delicious curry. Banana leaves were and to a certain extent still are used to wrap and serve food as a substitute for plates. Old people still remember the special taste of food wrapped in banana leaves. The banana leaves and fruits are often used for cultural and religious ceremonies. Leaves and other waste are used for animal fodder after harvesting and fibres can be extracted from the leaf sheaths.

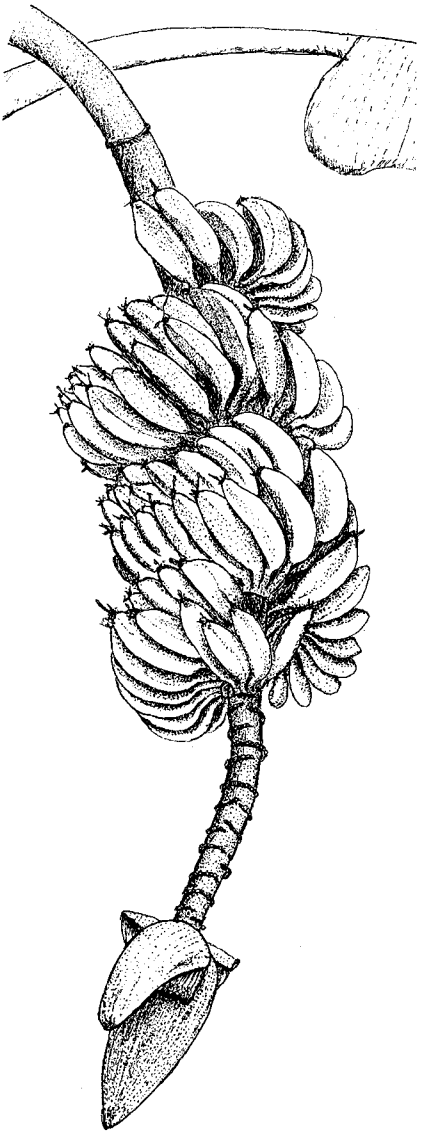


Figure 3.12. Fruits and flower of the banana

Papaya, *Carica papaya*
Caricaceae

The tree was introduced from Central America but is now widespread across the island. It is mainly found close to the kitchen pit where it probably germinated from seeds thrown away there. The papaya is easy to grow as it is not fastidious in its requirements of soil, water and climate. The fruits are mainly used for family consumption, surplus production is sold at the local market. Ripe fruits cannot be transported and must be handled carefully as they are sensitive to bruising. They can only be stored for a few days.

Coffee, *Coffea arabica*
Rubiaceae

All of the cultivated species of coffee originated from Africa. In Sri Lanka the commercially important types are *Coffea arabica, C.robusta* and sometimes improved varieties like *C.liberica*. Coffee was introduced by the British and was the first plantation crop cultivated in monoculture until a break down occured due to a wide spread fungus disease (*Hemilea vastratrix*). Today coffee is only grown on a small scale and does not contribute to the world market, which is dominated by South America. Processing the beans is mostly done using the drying method: sun drying, removal of pulp, winnowing, roasting and grinding. This method only produces low quality coffee. More information about harvesting and processing could upgrade the quality in many ways.

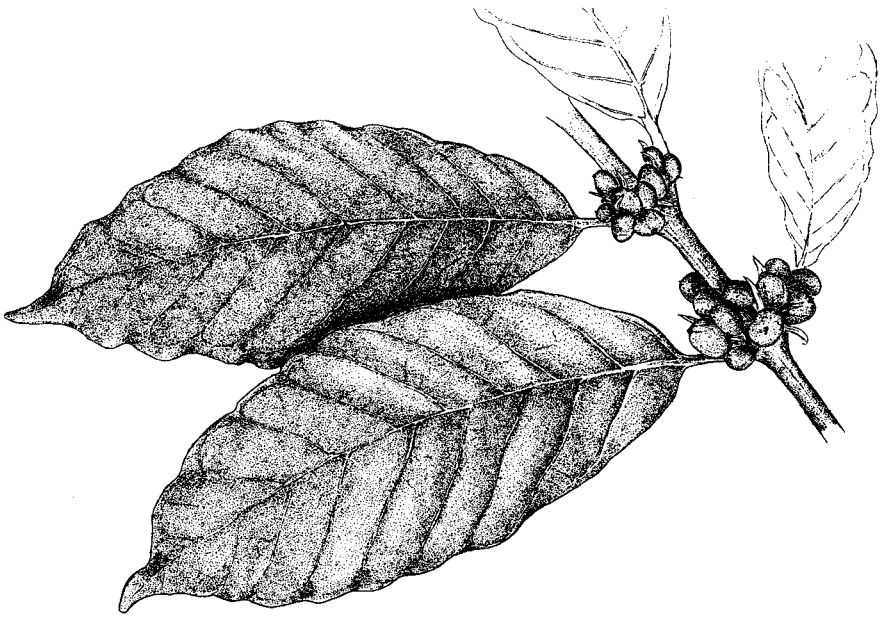


Figure 3.13. Coffee fruits

Guava, *Psidium guajava*
Myrtaceae
The guava tree originated in tropical America but can now be found everywhere in the tropics. In Sri Lanka it is more common to the wet zone. The guava tree is a tough and undemanding species. It is one of the group of fruit trees grown within a close distance to the house. The tree does not grow much higher than 5m to 7m. The fruit is seldom eaten raw but it is well suited for a number of canned goods such as juice, nectar, jam, jelly and syrup.

Curry leaf, *Murraya koenig*
Rutaceaei
This species is called "curry picha" in Sinhala because the leaves are used as flavouring in curries. They are generally used fresh in fish or vegetable curry where they give a very distinctive flavour. The tree is mostly found close to the kitchen and because of the continuous plucking of leaves it never grows to big dimensions. Therefore it might be even more abundant than our statistics show as it is easily overlooked.

Manioc, *Manihot esculenta*
Euphorbiaceae
The manioc originated from America and has now spread to other parts of the world. The different types of the species *Manihot esculenta* are not easily distinguished from each other. Manioc is a wholesome food containing an abundance of carbohydrate, it is easy to grow and requires little maintenance. It is not season bound but can be uprooted all year round. Manioc is a potentially poisonous plant. Tubers should be consumed fresh and undamaged to decrease the danger of poisoning.

Citrus Fruit, *Citrus sp.*
Rutaceae
The genus citrus originated from South Asia. In Sri Lanka the sour orange, *Citrus aurantium* , the lime *Citrus aurantiifolia* and the sweet orange, *Citrus sinensis* are found in the *gewatta* system. The citrus is a popular tree grown close to the house. The fruits are used for cooking and as medicine and the plants are said to keep insects away from the house.

- **Less common shrub species**

The above listed species occur frequently in the shrub layer of the *gewatta* system. Further species which are planted and maintained are less common. Most of them produce fruits, spices or beverages. Sometimes the surplus is sold and provides some income for the family.

The following list names some less important species of the shrub layer in percentage of occurrence:

Punica granatum	24%	food, medicinal plant, ornamental value
Annona muricata °	21%	food, animal habitat
Annona reticulata °	14%	food,
Theobroma cacao °	21%	export product, flavouring agent, food
Flacourtia inermis	14%	food
Cassia auriculata	4%	medicinal plant, tea, beverages
Elletaria cardamomum	11%	export crop, flavouring agent,

°Introduced species

- **Species with ornamental value cultivated for cultural or religious purposes:**

Some shrubs are cultivated for their ornamental value. As flower offerings in the temple are a common custom most of the *gewattas* include flowering shrubs such as *Hibiscus rosa-sinensis* (occurs in 48% of the surveyed gardens), *Codiaeum variegatum* (44%), *Jasminum sp.* (31%) and *Plumeria acuminata* (11%). They contribute much to the charm and beauty of the rural dwellings.

In this survey no emphasis was layed on a complete documentation of ornamental plants, therefore only a few main representatives of this group were listed. In total the number of species varies between 20 and 60 depending on life style and region as well as on the social background of the farm family. In urban areas it is possible to observe a more intensive cultivation of ornamental plants whereas remote villages are still characterised by the "traditional" stock of plants mainly used for religious and cultural purposes.

The following list names some of the more common ornamental species in % of occurrence:

Rosa sp.	*28%*	*Bougainvillea sp.*	*7%*
Polyscias sp.	*21%*	*Polyscias balfouriana*	*6%*
Ervatamia divaricata	*14%*	*Mussandra frondosa*	*6%*
Cestrum elegans	*12%*	*Jatropa podagrica*	*3%*
Allamanda cathartica	*10%*	*Saraca indica*	*2%*
Sambucus sambac	*7%*		

- **Species which represent the natural undergrowth of forest in the specific area:**

Some plants of the shrub layer are propagated by wild germination only and represent the natural undergrowth of forest in the specific area. These species are highly variable depending on regional environmental conditions as well as adjacent vegetation. Some of them are valuable medicinal plants.

The following list names some of the more common plants in % of occurrence:

Sauropus androgynus	34%	food, hedge plant
Pavetta indica	19%	medicinal plant
Cipadessa baccifera	18%	toys for children
Flueggea sp.	6%	not documented
Clerodendron infortunatum	6%	medicinal plant
Glycosmis pentaphylla	4%	medicinal plant
Glycosmis mauritiana	3%	not documented
Hiptaghe bengalensis	3%	not documented
Calamus sp.	3%	light industries, furniture, toys
Smilax zeylanica	2%	medicinal plant

3.5.5. Climbers

Climbers occupy a special niche in the *gewatta* system. They have developed special strategies to satisfy their requirements of light and nutrients. Most of them require support plants to climb on. Some species are planted and maintained to produce food and spices, often as a means to earn surplus income, or medicine. For these climbers people select support plants or use simple constructions like strings to plant them in the optimal way. Some species grow wild.

The following list names the most common climbers listed in % of occurence:

species	in %	cultivation	uses
Piper nigrum°	67%	grown from cuttings	export crop, spice, medicine
Dioscorea sp°.	44%	cultivated with tubers	starch plant
Passiflora sp°.	30%	seeds and cuttings	fruits, ornamental value
Clitoria ternatea	22%	wild germination	medicine, ornamental value
Piper betle°	27%	grown from cuttings	medicine, stimulant
Asparagus falcatus	12%	not documented	medicine, ornamental value
Vanila planifolium°	4%	propagation by cuttings	flavouring agent, market product

° Introduced species

Within the group of climbing plants 17 species were documented. Two different groups could be distinguished:

1. Species planted and maintained, producing food, medicine or surplus income
2. Wild growing species with some use as food or medicine

- **Species planted and maintained, producing food, medicine or surplus income:**

Pepper, *Piper nigrum*
Piperaceae
Piper nigrum is a typical cash crop component of the *gewatta* system. The local varieties are easy to propagate and maintain, they are not fertilised and they are resistant against pest and diseases. Mostly they are grown on *Gliricidia sepium* which acts as a support plant. Flowering takes place from September to November and the crop ripens from March to May.

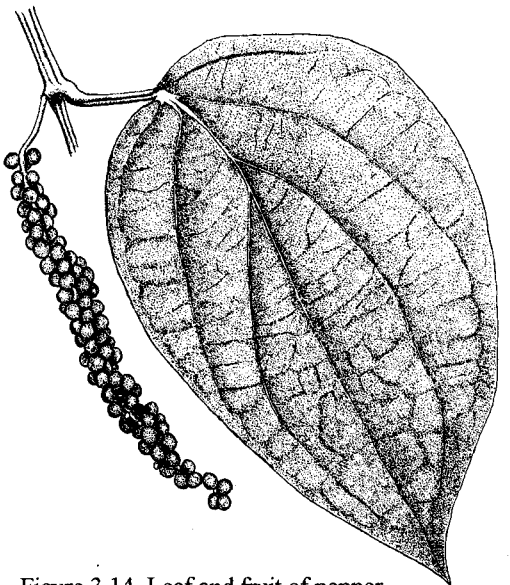


Figure 3.14. Leaf and fruit of pepper

Yam, *Dioscorea sp.*
Dioscoreaceae
The genus *Dioscorea* has hundreds of species and is distributed throughout the tropical and subtropical world. In the surveyed *gewattas* mainly *Dioscorea alata* was observed but different species can also be found. The tubers are mainly used for family consumption. Most of them are cultivated on stakes.

Passion Fruit, *Passiflora sp.*
Passifloraceae
The genus originated from America, though today a huge number of different species are grown in Sri Lanka as ornamental plants. About 20 species have edible fruits (Rehm, 1991). The passion fruit can also be prepared as a beverage. Regular pruning and training of the climbing plant is necessary to produce fruits.

Clitoria ternatea
Leguminosae
The plant is a typical climber of the *gewatta* system. It germinates by wild propagation and is never planted or cultivated intentionally. People do not regard it as a weed, though the plant is quite competitive, but tolerate it for its medicinal and ornamental value.

Betel vine, *Piper betle*
Piperaceae
The plant is of great importance in many religious and cultural ceremonies. The leaves are used for offerings at the temple and they are for example, part of the buddhist wedding ceremony. The leaves are sold at the market and mostly used as wrapping for the betel nut (*Areca catechu*) slices. They are an important component of the betel bite together with the betel nut. The taste of the leaves is stimulating and aromatic.

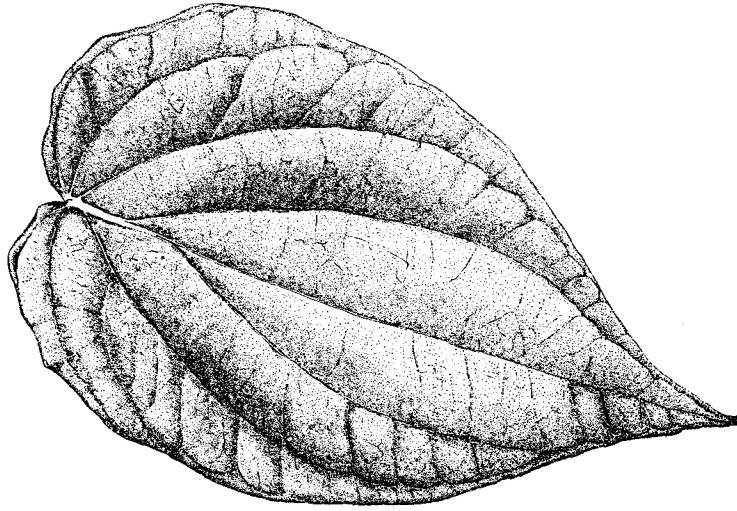


Figure 3.15. Betel leaf

Asparagus falcatus* and *Asparagus racemosus
Liliaceae
Both plants are cultivated for their ornamental as well as their medicinal value.

Vanilla, *Vanilla planifolium*
Orchidaceae
Vanilla is a valuable spice which is not commonly grown. Outside of its homeland (Central America) the bees and humming birds which are necessary for its pollination are absent. It therefore needs some skill to pollinate the plant by hand. It can be grown in shady conditions within the *gewatta* system and provides surplus income for the farmer.

Wild growing species with some uses as food or medicine:

Mikania cordata	56%	fodder, regarded as weed
Syngonium angustifolium	35%	
Cardiospermum halicacarbum	23%	medicine
Argyreia populifolia	21%	medicine
Abrus precatorius	9%	medicine, toys for children
Coscinium fenestratum *	3%	medicine, whips
Cissampelos pareira	8%	medicine
Cyclea burmanni	4%	medicine, whips
Piper sylvestre	2%	

* Endemic species

Figure 3.16. *Cardiospermum halicacarbum*

3.5.6. Undergrowth

The undergrowth of a traditional *gewatta* with forest-like canopy cover is highly heterogenous. However, due to the dense crown cover, sunlight is a limiting factor for the undergrowth and we can distinguish different groups of herbs, those requiring adequate sunlight, and those which are shade tolerant. Therefore the composition of species found within the undergrowth varies according to the effects of light and human management. Close to the house, where a small compound is cleared from trees, light demanding species like chillie (*Capsicum sp.*) or *Pandanus sp.* can grow well.

Further into the interior of a *gewatta* some of the more shade tolerant plants such as yams (*Colocasia esculenta)* will be planted.

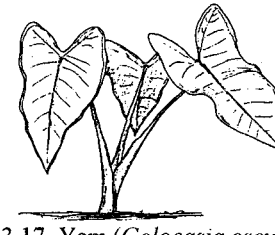


Figure 3.17. Yam (*Colocasia esculenta)*

In total 264 different plant species were documented as belonging to the undergrowth. Although tree species form the visually and structurally most important component of the *gewatta* system, the undergrowth, however, contributes a major part to the floristic richness of a *gewatta*. Furthermore fresh green leaves from many different species are an important component of Sinhalese meals. We found the custom of preparing a dish in Sinhala called *mellum*, where fresh, green leaves are chopped and mixed with coconut, lime and spices, to be widespread.

Three different types or groups of plants can be distinguished within the undergrowth:

1. Planted and maintained herbs
2. spontaneous but tolerated herbs
3. spontaneous herbs regarded as weeds.

- **Species planted and maintained for food, spices, medicinal uses or ornamental use, many of which are light-demanding and planted close to the house:**

Most most common light demanding species listed in % of occurrence

Capsicum sp.	53%	main flavouring agent of traditional curries
Curcuma longa	45%	medicine, flavouring agent, religious ceremonies
Pandanus sp.	45%	flavouring agent
Tagetes erecta	43%	ornamental plant, insect repellent, religious ceremonies
Zingiber officinale	40%	flavouring agent, medicine

The following plants are commonly found near the kitchen as they are an indispensable ingredient of traditional Sinhalese meals, particularly for curries:

Chilli, *Capsicum sp.*
Solanaceae
The plant originated in America but is now the most widespread spice in the tropics. In Sri Lanka dried chillies play an important part in the preparation of curries. There are many different varieties, differing in shape and size. The chillie when ripe is generally red, chillies that are comparably thin with a smooth pericarp have the highest piquancy and are used as condiments for curry.

Turmeric, *Curcuma longa*
Zingiberaceae
The rhizom of this plant is used in curries. Tumeric as such does not give much of a flavour but it is used in every curry, as it adds colour to the food and is considered to be purifying. Hindu places of worship are sprinkled with turmeric water every morning.

Pandanus sp.
Pandanaceae
Pandanus sp. is a long leaf with a certain percentage of volatile oils. It gives a strong aromatic flavour when fried in oil or even when heated in a pan. Usually the leaves are cut, dried and stored or used fresh.

Ginger, *Zingiber officinale*
Zingiberaceae
Ginger is a rhizom and there are two varieties found in Sri Lanka. One is very pungent and fibrous. It is mainly used fresh, chopped and sliced, or as powder after it has been cured and sundried. The second variety is fibreless when it is young, the taste is mild and it is generally used in the preparation of syrup.

In some of the visited *gewattas* a small vegetable plot had been established: Usually only local vegetable species are grown in the *gewatta* system. The introduced vegetable species such as cabbage, beet, carrot, leek, radish, lettuce, cauliflower and peas require adequate sunlight, watering and maintenance.

The following list names some vegetable species in % of occurrence:

Xanthosoma sagittifolium	40%	starch plant
Ananas comosus	37%	fruit, market product
Colocasia esculenta	37%	starch plant, wrapping, decorations, medicine
Anthurium sp.	37%	ornamental plant, market product
Solanum melongena	30%	vegetable
Ipomoea batatas	27%	starch plant,
Cucurbita maximum	21%	vegetable
Saccharum officinarum	19%	sugar, medicinal plant
Lycoperiscum esculentum	18%	vegetable
Alocasia macrorhiza	18%	wrapping, fodder, decorations (weddings)
Momordica charantia	15%	vegetable, medicine
Psophocarpus tetragonolobus	12%	vegetable
Sechium edule	6%	vegetable
Phaseolus lunatus	4%	vegetable
Ipomoea aquatica	3%	vegetable

- **Self germinating species maintained and used for food or medicine:**

A great number of local leafy vegetables are found in the *gewatta* system. Most of them germinate by wild propagation, they are very well adapted to the shady and moist conditions of the *gewatta* system and do not require any maintenance. Only a few are light demanding and will therefore be confined to light patches and open parts of the garden. People regard them as very useful and healthy, in fact many of these plants are rich in mineral salts, particularly iron, carotene and vitamins.

The following list names some species of this group in % of occurrence:

Centella asiatica	49%	leafe vegetable, medicine, soil stabilizer
Alternanthera sessilis	33%	leafe vegetable, medicine, soil stabilizer
Solanum indicum	27%	vegetable, medicine
Amaranthus (tricolor, oleraceus)	31%	vegetable, medicine
Ricinus communis	18%	medicine
Basella alba	12%	vegetable, medicine, dyes and tannins
Lasia spinosa	11%	vegetable, medicine
Aloe vera	10%	medicine

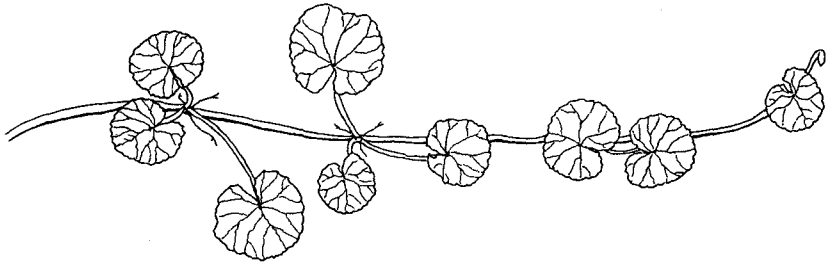


Figure 3.18. Centella asiatica

- **Self germinating species, tolerated because of their medicinal values or because of their use as fodder**

Unlike in other agricultural systems weeds are generally not a major problem for the farmer. Due to the forest-like character of the vegetation with ist dense crown cover most of the herbal plants cannot dominate or displace useful species. Many of the herba species are not declared as weeds but are an important fodder and sometimes used for medicinal or other purposes. Additionally, these plants act as soil stabilizers in sloping terrain and have a positive effect on the micro-climate.

The following list names some plants of this group in % of occurrence:

Aerva lanata	25%	*Cyperus rotundus*	15%
Achyranthes aspera	18%	*Acalypha indica*	13%
Vernonia cinera	35%	*Oxalis corniculata*	11%
Panicum maximum	30%	*Biophytum reinwardtii*	12%
Axonophus affinis	30%	*Eleusine indica*	12%
Stachytarpheta (indica, urticifolia)	29%	*Tithonia diversifolia*	8%
Setaria sp.	21%	*Euphorbia heterophylla*	8%
Hedyotis sp.	24%	*Kalanchoe pinnata*	8%
Impatiens sp.	23%	*Ocimum sanctum*	5%
Phyllanthus debilis	16%	*Calotropis gigantea*	2%
Sida acuta	16%		

- **Self germinating species not regarded as useful, indicating site quality and adjacent vegetation**

The dividing line between weeds and tolerated but unused species is difficult to establish. Out of the 480 most common species selected only 42 had no specific use and were regarded as wild plants. Most of them were tolerated and not declared as weeds. Sometimes farmers admitted to being not experienced enough to know about these plants. In their way of thinking this leaves the possibility open that any of these plants could be useful for something still unknown.

The word weed is not found in Sinhala, the farmers mostly say: " this plant is wild growing (*wal* in Sinhala) and has no use". Most of them are herbs and grasses belonging to the spontaneous vegetation of disturbed sites. Some of them were declared as useful for medicine, food, and fodder or were of ornamental value.

The amount of weeding practiced by farmers varies. In the surveyed *gewattas* weeding was mostly done after the rainy season. From 103 farmers questioned 39 weeded only twice a year. 17 farmers stated they weeded once a month. 10 farmers replied that they never did any weeding and only one farmer claimed to weed every week.

Only a very small number of plants can be seen as weeds. Despite the generally self-regulating nature of the *gewatta*, some climbing plants such as *Mikania cordata* would definitely suppress its support plant, and without human management certain dominant species would displace cultivated and useful plants. *Eupatorium odoratum*, for instance, is called "*Danapatti nattan*" which translated from Singhalese means "the rich man's death". "*Podi singho marang*" is a similar expression meaning "the death of a good reputation". Both names refer to the dominant and suppressive character of the plant. Few plants are addressed in this manner though it is interesting to note that people occasionally address different species with the same name because the character of these weeds is similar. *Dicranopteris linearis*, *Imperata cylindrica*, *Mikania cordata*, and *Eupatorium odoratum* belong to this group. Farmers know that they have to control these plants because otherwise they would displace more useful species.

The following list names some plants of this group in percentage of occurrence:

Mikania cordata	56%	*Gynura sp.*	14%
Eleutheranthera ruderalis	50%	*Lantana camara*	14%
Pteris biaurita	48%	*Digitaria sp.*	12%
Adiantum sp.	36%	*Dicranopteris linearis*	11%
Eupatorium odoratum	33%	*Imperata cylindrica*	9%
Cyrtococcum sp.	26%	*Oplismenus compositus*	5%
Commelina diffusa	22%	*Synedrella nodiflora*	4%

Thus one can see that species diversity in all layers of the *gewatta* system is a vital precondition of its success. It prevents the establishment of a few dominant species and thereby reduces the farmers' workload. The abundant source of fruits, vegetables, and fresh green leaves provides wholesome food and variety in the kitchen together with traditional medicines. A great variety of useful by-products contribute to the families'

welfare. Added to this the herbaceous vegetation is important as soil cover and stabilizer, without which future harvests would be threatened.

The results of these chapters show that the species composition of the *gewatta* system is dependant on farmers' decisions about the usefulness of plant species. Provided that adjacent vegetation is rich and diverse the homegarden will shelter a great variety of wild species which are incorporated without clear distinction from planted species. The traditional skills and knowledge endowed from one generation to the next is one of the main factors for maintaining species other than for commercial reasons.

The mapping of a plot measuring one square metre shows a typical mix of herbaceous species as is commonly found in the *gewatta* system.

Figure 3.19. Typical undergrowth of the *gewatta* system.

Sauropus androgynus, Mikania cordata, Axonopus affinis, Rejoua dichotoma, Sida acuta, Cyrtococcum sp., a seedling of *Neolitsea cassia* and unidentified grass species.

3.5.7. Species Diversity of the *Gewatta* System

A very interesting result of the floristic survey was the relative small variation in the floristic diversity of the *gewatta* system. The number of species and life forms was homogeneous throughout the survey and the average number of species was constant compared to the variation of garden size. Species diversity can therefore be called the most important and basic criteria of the *gewatta* system (A total of 640 different plant species including trees, shrubs climbers and herbs were documented).

According to the daily requirements of rural people the gewatta has some common features in the species assembly. The following list names the most common plants of the different structural layers of an average gewatta.

trees	**shrubs**	**herbs**	**climbers**
Artocarpus heterophyllus	*Musa spp.*	*Capsicum annuum*	*Piper nigrum*
Cocos nucifera	*Carica papaya*	*Manihot esculentum*	*Dioscorea alata*
Mangifera indica	*Coffea robusta*	*Eleutheranthera ruderalis*	*Passiflora sp.*
Areca catechu	*Psidium guajava*	*Pteris biaurita*	*Piper betle*
Caryota urens	*Murraya koenigi*	*Curcuma longa*	*Asparagus falcatus*
Gliricidia sepium	*Citrus sp.*	*Pandanus sp.*	*Syngonium angustifolium*
Persea americana	*Annona sp.*	*Centella asiatica*	*Mikania cordata*
Syzygium aromaticum	*Punica granatum*	*Tagetes erecta*	
Macaranga peltata	*Rosa sp.*	*Zingiber officinale*	
Artocarpus altitis	*Sauropus androgynus*	*Alternanthera sessilis*	

Out of 640 species 7 tree species were found in more than 70% of the surveyed gardens and 10 tree species, 5 shrubs, 2 climbers and 4 herbs were found in more than 50%. These species form the „typical" species assembly of a traditional gewatta, provided the topographic and climatic conditions and social set up of the villages do not differ too much from the average conditions.

The average number of species found in the *gewatta* system was documented with 53 species of trees, shrubs, climbers and herbs. If we deduct the common species 32 species (about 60%) remain which are different in all of the studied sites. The variation is dependent on different factors like the adjacent vegetation and the forest community of the region, the economic set up of the village and the cultural background. Undergrowth as well as climbers do not vary to the same extent as trees and shrubs, and are with few exceptions similarly distributed within the survey.

The diversity of species, however, is a result of different historical factors. Some gardens are created as forest-like systems. Some of them were once cleared land or former plantation areas which were interplanted with many useful species and enriched by spontaneous vegetation. Others have never been cleared but were forest lands which were influenced more and more by selective felling or occasional interplanting. Another group of gardens, established on former shifting cultivation areas, were a transformation from the slash and burn system towards a homestead garden system.

It is important to state that the subtle management of the gewatta system as it is practised by rural people in Sri Lanka does not resemble one generalized method of land utilisation. Rather we find a great variety of different resource management practices which are changeable and not at all static.

These results are comparable to corresponding studies carried out in different parts of Sri Lanka. A survey of fifty households in two villages, Bambarabedda and Madugalla in Kandy District (WICKRAMASINGHE 1992) brought similar results of species compositon. According to this study *Artocarpus heterophyllus, Cocos nucifera, Mangifera indica, Artocarpus altitis, Gliricidia sepium* and *Coffea arabica* were preferred by farmers selection and frequently found in the gardens.

Another survey of 30 gardens in Kandy district described the most important crops as being *Areca catechu, Artocarpus heterophyllus, Cocos nucifera* and *Piper nigrum* (JACOB AND ALLES 1983).

A different study from the Central Province, Welimada and Kotmale Division carried out in 1985/86 (Everett, unpublished draft) shows similar findings. In the 173 gardens surveyed a total of 143 species of woody perennials were identified. 37% of these plants were forest species.

In Pilimatalawe the flora in and around two gardens (within 1.6km) was observed. 262 species, 107 trees (38 wild), 69 shrubs (37 wild) and 86 herbs (64 wild) were documented (MENDIS 1989).

Perera et al. documented a total of 125 (61 tree, 12 shrub, 10 climbers and 42 herbaceous) species with a mean number of 46 species out of 50 gardens surveyed (PERERA AND RAJAPAKSE 1991).

The results of McConnell do not show a comparable number of species, with an estimate of 29 species per garden which can be explained by the small number (30) of gardens surveyed and the dominance of tea cultivation (MCCONELL 1992).

Similar systems found in other tropical parts of the world are comparatively diverse:

- Indonesia - an average of 56 species per household (SOEMARWOTO, 1985)
- Bantar Kalong - 196 species in 36 gardens (BOMPARD et al., 1980)
- West Java - Citarum watershed - 500 species in 351 gardens (KARYONO, 1981)
- Yucatan, Mexico - Tixpeual, Tixacaltuyub - 135 species in 20 gardens (RICO-GRAY et al., 1990)
- Chiapas, Mexico - 241 species in 30 gardens (VOGL, 1998)

These figures show that the system of tree dominated homegardens has evolved similarly in different parts of the tropics. In different cultural contexts with similar environmental conditions rural people have developed a comparable system of land use. In our opinion this fact is of great importance for any further and better understanding of these age-old agricultural systems. The main factor determining the sustainable production over a long period of time was the forest-like character of the plant community. Species diversity can be called the key factor of these systems.

Our investigations show that the undergrowth contributes a major part, namely 58.7%. to the diversity of the plant community. Trees, though they dominate the structural features, are of secondary importance for the diversity of the gewatta system. They contribute 32% to the total species diversity. Besides this factor the undergrowth has a positive effect on soil conditions. erosion control and fauna. The relatively low amount of soil loss in the gewatta system estimated with 0.5 MT/Ha/Yr is very much lower than the accepted tolerant limits (KOTTEGODA, WICKRAMASINGHE 1989, 24). Crown cover and the amount of shading as well as slope conditions influence undergrowth and soil loss. Undergrowth is determined by different factors, like the age of the garden, management, species composition, litter layer, soil conditions and microclimate. The interrelation between trees and structural components and the undergrowth can be verified but we cannot establish a direct correlation between crown cover and undergrowth density.

Diversity of trees, shrubs and climbers of the *gewatta* system is partly dependent on farmers' preferences and partly on the geographic location. The gewattas are characterized by permanent subtle management like interplanting and selection of seedlings. In our opinion farmers' attitudes, knowledge, and social as well as cultural background determine a high percentage of the plant community of the gewatta system. Therefore the next chaper will give a more detailed description of the different uses of plants. The usefulness is an important factor for the selection of species. Every single garden visited was a unique assembly charcterizing the inhabitants preferences and attitudes. Therefore no generalized answers and solutions are ready for an improvement of the gewatta system.

3.6. Ethnobotany of the *Gewatta* System

3.6.1 Introduction

Out of a total of 640 species documented in the 158 gardens, the 480 most common species were selected[1]. Different categories of uses were identified with the help of farmers. The main components of a gewatta include timber and fuel-wood, vegetables, fruits and other food items, fodder, medicinal plants, cashcrops, ornamental plants, plants of cultural or religious significance, plants important for the structural features of the garden, plants for erosion control, and plants providing shade. Most of the species are multipurpose and contribute many useful by-products for the daily life of rural people.

In order to get reliable data on the products harvested in a gewatta, three farmers documented their consumption pattern for us (Arambegama, Welianga, Lewella). The extraordinary helpfulness of those farmers and their interest in our work enabled us to develop a small data base on homegarden products over the course of one year.

The data presented gives a general overview of the diversity of products and the manifold gifts provided by the gewatta system. In the following section we have recorded the most important categories of uses. Rather than simply presenting the patterns of consumption we have combined these results with an extended commentary, thus enabling the reader to gain an insight into the farmers' attitudes and their way of life. This method resembles a walk through the gewatta accompanied by the farmer who stops here and there to explain and discuss different problems.

3.6.2. Wood - Uses

Timber

A total of 70 species of timber trees were documented in the surveyed gewattas, they are listed in table 3.2. Timber trees often form an important structural component of the system. In most cases timber is only a by-product beside food and fuel-wood. The trees are used for the construction of houses, small bridges, furniture, tools, coffins and many other functions.

Usually people do not regard timber as a cash crop. Nevertheless for small scale farmers timber trees serve as a "savings bank". Rapid cash income can be provided when they decide to cut a tree. As farmers told us big trees are mainly cut in April and May. Due to religious attitudes some species are regarded as sacred and they are never used for timber (for example *Ficus religiosa, Ficus benghalensis, Mesua ferreae*). In our interviews we included a question on whether farmers were willing to cut the trees for money and to what extent they would be willing to cut them. Most of the farmers did not answer clearly but a general trend could be observed in a statement often heard: "We do not grow our trees to cut them." Generally it seems that tree borne food, fuel,

[1]A complete list of plants and their utilization is shown in the appendix. In the following paragraph only the most important species are named

and many other products are regarded as valuable products and felling a tree for timber is only done when it is absolutely necessary.

Fuel-wood

A total of 77 species, listed in the following table (3.1.), were documented as sources of fuel-wood supply. For most of the surveyed houses firewood is still the only source of fuel for cooking. Collecting firewood is mainly the task of women. They usually have personal preferences regarding species and usage. Different meals or the processing and drying of spices need different temperatures and accordingly different species will be selected. Usually a mixture of different woods is used. The most common species are *Cocos nucifera, Artocarpus heterophyllus* and different timber trees like *Michelia champaca*. To light the fire coconut shells and leaves as well as twigs are preferred because they are easy to ignite, on the other hand jak branches and other hardwood species produce an enduring fire. Big branches are usually dried for about one month before use. The following table shows the firewood consumption of the three surveyed farms.

Table 3.1. Firewood consumpiton of three farms near Kandy

gewatta	size	kg/ year	kg/ month	species named in descending order of importance
Arambegama	2025m²	1289kg	106kg	*Michelia champaca, Cocos nucifera, Artocarpus heterophyllus, Mangifera indica, Melia dubia, Alstonia macrophylla, Persea americana, Coffea arabica*
Welianga	16200m²	2025kg	169kg	*Cocos nucifera, Grevillea robust, Artocarpus heterophyllus, Swietenia macrophylla, Gliricidia sepium, Pesea americana, Artocarpus altilis, Syzygium aromaticum, Myristica fragrans*
Lewella	4050m²	910kg	76kg	*Artocarpus heterophyllus, Cocos nucifera, Coffea arabica, Michelia champaca, Gliricidia sepium, Theobroma cacao, Mangifera indica*
Average	7425m²	1408kg	117kg	

The results probably tend to underestimate the true fuel-wood consumption by about 25 to 30 percent. The average daily consumption calculated according to the information of the three surveyed farms would make 3.9kg. We can assume that the measurements taken were not truly accurate. However, all three farmers stated that they were self-sufficient in their fuel-wood production. Further investigations on this topic seem warranted.

Tools
17 different species were recorded including a huge variety of useful tree products like ladders, pipes, brooms, furniture, tools for agriculture as well as kitchen utensils, stuffing material for pillows, umbrellas from the leaves of the Ola palm (*Corypha umbraculifera* is still used by Buddhist monks), to name some examples.

Toys
13 species were documented including seeds to prepare necklaces, fruit shells for masks and puppets, pots, small weapons or carved models for children.

The following table shows some of the important timber and fuel species with various other uses. The complete list of uses can be seen in the appendix.

Table 3.2. Important timber and fuel species.
Abbreviations used as follows: T...timber, F... fuel, To...tools, Ty... toys, Fi... fibres, G...gums, Fo... fodder, So... soil conservation, Su... support plant, W... wrapping, P... pionier, R... plants with religious importance, D... dyes

Family	Species	T	F	To	Ty	Fi	G	Fo	So	Su	W	P	R	D
RUBIACEAE	*Adina cordifolia*	X	X											
LEGUMINOSAE	*Albizia lebbeck*	X	X						X			X		
LEGUMINOSAE	*Albizia odoratissima*	X	X						X			X		
APOCYNACEAE	*Alstonia macrophylla*	X	X						X			X		
APOCYNACEAE	*Alstonia scholaris*	X	X	X	X									
ANACARDIACEAE	*Anacardium occidentale*	X					X							
PALMAE	*Areca catechu*	X	X	X					X	X	X		X	X
MORACEAE	*Artocarpus altitis*	X	X								X			
MORACEAE	*Artocarpus heterophyllus*	X	X		X			X					X	X
MORACEAE	*Artocarpus incisus*	X	X											
MORACEAE	*Artocarpus lackoocha*	X	X											
MORACEAE	*Artocarpus nobilis*	X	X											
MELIACEAE	*Azadirachta indica*	X											X	
BAMBUSACEAE	*Bambusa vulgaris*	X	X	X	X				X	X			X	X
TILIACEAE	*Berrya cordifolia*	X	X								X			
BOMBACACEAE	*Bombax ceiba*	X	X	X										
ANNONACEAE	*Cananga odorata*	X	X									X		
BURSERACEAE	*Canarium zeylanicum*	X												
RHIZOPHORACEAE	*Carallia brachiata*	X	X											
PALMAE	*Caryota urens*	X	X	X		X		X						X
MELIACEAE	*Cedrellus toona*	X	X										X	
BOMBACEAE	*Ceiba pentandra*	X		X										

Family	Species	T	F	To	Ty	Fi	G	Fo	So	Su	W	P	R	D
RUTACEAE	*Chloroxylon swietenia*	X	X											
PALMAE	*Cocus nucifera*	X	X	X	X	X		X		X	X		X	
EBENACEAE	*Diospyros ebenum*	X		X										
EBENACEAE	*Diospyros insignis*	X	X											
EBENACEAE	*Diospyros koenigii*	X	X											
EBENACEAE	*Diospyros malabarica*	X	X											
EBENACEAE	*Diospyros sylvatica*	X												
EUPHORBIACEAE	*Drypetes sepiaria*	X	X											
BOMBACEAE	*Durio zibethinus*	X	X											
MYRTACEAE	*Eucalyptus sp..*	X	X											
SAPINDACEAE	*Filicium decipiens*	X	X											
PROTEACEAE	*Grevillea robusta*	X	X						X	X				
SAPINDACEAE	*Harpullia arborea*	X	X											
EUPHORBIACEAE	*Hevea brasiliensis*	X	X		X		X							
SAPOTACEAE	*Madhuca longifolia*	X	X						X					
ANACARDIACEAE	*Mangifera indica*	X	X					X					X	
ANACARDIACEAE	*Mangifera zeylanica*	X	X										X	
SAPOTACEAE	*Manilkara zapota*	X	X											
MELIACEAE	*Melia dubia*	X	X											
GUTTIFERAE	*Mesua ferrea*	X											X	
GUTTIFERAE	*Mesua nagasarium*	X												
MAGNOLIACEAE	*Michelia champaca*	X	X											
LAURACEAE	*Neolitsea cassia*	X	X											
SAPINDACEAE	*Nephelium longana*	X	X											
ANACARDIACEAE	*Nothopegia beddomei*	X	X											
LEGUMINOSAE	*Pericopsis mooniana*	X												
LAURACEAE	*Persea americana*	X	X					X						
EUPHORBIACEAE	*Phyllanthus indicus*	X	X											
PINACEAE	*Pinus carebaea*	X	X											
PITTOSPORACEAE	*Pittosporum ceylanicum*	X	X											
LEGUMINOSAE	*Pterocarpus indicus*	X	X									X		
LEGUMINOSAE	*Pterocarpus marsupium*	X	X											
LEGUMINOSAE	*Pterospermum canescens*	X	X											
LEGUMINOSAE	*Samanea saman*	X	X									X		
SAPINDACEAE	*Schleichera oleosa*	X	X											
ANACARDIACEAE	*Semecarpus nigroviridis*	X	X											
BIGNONIACEAE	*Stereospermum suaveolens*	X	X											

Family	Species	T	F	To	Ty	Fi	G	Fo	So	Su	W	P	R	D
MELIACEAE	*Swietenia mahagoni*	X	X											
MYRTACEAE	*Syzygium cumini*	X	X											
LEGUMONISAE	*Tamarindus indica*	X	X											
VERBENACEAE	*Tectona grandis*	X	X											
COMBRETACEAE	*Terminalia belerica*	X												
COMBRETACEAE	*Terminalia catappa*	X	X									X		
MALVACEAE	*Thespesia populnea*	X	X						X					X
STAPHYLEACEAE	*Turpinia malabarica*	X												
DIPTEROCARPACEAE	*Vateria copallifera*	X												
VERBENACEAE	*Vitex altissima*	X												

3.6.3. Food - Uses

Fruits

39 species of different fruits as listed in table 3.3. were documented, providing valuable nutrients as well as surplus income for the farmer. Most of the fruit trees are found close to the house. Each species of the various fruit trees is harvested at a different time throughout the year. Citrus trees (*Citrus sp.*), for example generally flower at the beginning of the rainy season (April, May), while other fruits like mango and avocado flower during the dry season (December, January). Some species like Coconut (*Cocos nucifera*) or Papaya (*Carica papaya*) bear fruits throughout the year. Most of the harvested fruits are used for home consumption and only the surplus is sold providing extra income.

Local varieties and genetic diversity is still not documented sufficiently. The genetic variety has only recently been acknowledged and this has led to research projects being started on this topic. Likewise preservation and transportation as well as the processing of fruits are still to be improved to better farmers' income.

An average of 700 different pieces of fruits including 36 bunches of bananas (*Musa spp.*) and 45 papayas (*Carica papaya*) were said to be consumed by the average farm family in one year. Besides banana and papaya which were mainly used as dessert, the most popular fruits were mango (*Mangifera indica*), avocado (*Persea americana*), and mangostean (*Garcinia mangostana*).

Vegetables

62 species, listed in table 4, were recorded. Tree borne food, vegetables, or leaves from perennial herbs enrich daily meals for the farm family. It is noticeable that most of the vegetable plants of the gewatta system germinate by wild propagation, only a few of them are planted by the farmer. Cultivated species which are often light demanding are planted close to the house, mostly near the kitchen. Usually a gewatta has no vegetable plot as such. The vegetable plants are found throughout the garden where they occupy different niches. Climbers like *Dioscorea alata* will be planted near suitable support plants, yams like *Colocasia esculenta* are more shade tolerant and will be found in the

undergrowth, edible herbs such *as Alternanthera sessilis, Centella asiatica, Basella alba* and *Lasia spinosa* grow randomly distributed in the ground layer of the garden.

As stated earlier the gewatta is not traditionally used for vegetable cultivation. The garden is a place for "wild foods" collected without much effort or maintenance. Today vegetable cultivation within the gewatta varies with the farmers' skills and interests. The closed crown cover of a traditional garden does not allow intensive cultivation of light demanding vegetable species. The gewatta is usually not used for the cultivation of introduced vegetable species such as potatoes, carrots, beetroot, leeks or bush beans. On the contrary, many of the vegetables found in the gewatta system are indigenous plants. Tree borne food or wild growing herbs can be produced with comparatively minimal input of chemicals or energy.

A very important tree borne product of the gewatta system is the coconut (*Cocos nucifera*). The farmers documented an average of 243 nuts harvested per year and garden.

The jakfruit (*Artocarpus heterophyllus*) is a common ingredient of a traditional Sri Lankan meal, though recent changes in lifestyle have led to a decrease in its use. Accordingly our farmers documented only 2 to 12 fruits being consumed per year. Another fruit of the same plant family, the breadfruit, (*Artocarpus altilis*) is even less popular in Sri Lanka today, the farmers documented 5 to 10 fruits being consumed per year.

Plants with medicinal value

201 species were documented to be of medicinal value. Traditional knowledge is still widespread but because of the increasing availability of so-called "western medicine" people are tending to reduce the use of traditional remedies. Very common infections like influenza, stomach pain or small wounds are still treated with herbs from the gewatta.

The most commonly used species are: *Zingiber officinale, Curcuma longa, Citrus sp., Aloe vera, Pavetta indica, Acalypha indica, Aerva lanata, Asparagus racemosus, Azadirachta indica, Adenanthera pavonina, Piper nigrum, Myristica fragans, Ellateria cardamon, Mimosa pudica, Syzygium aromaticum, Ricinus communis, Cardiospermum halicacarbum.*

The dividing line between medicine and food is difficult to establish. According to the attitudes of farmers and to the aryuvedic system of medicine (the indigenous medicine of India and Sri Lanka) food is regarded as medicine. Any cooling effect of food, for example, is desirable. Likewise people ascribe different qualities, which is completely unknown to western thinking, to certain kinds of food.

Beverages

12 species including tea (*Camellina sinensis*), coffee (*Coffea arabica*) and cocoa (*Theobroma cacao*) were documented. Palm sap as well as beverages prepared from fruits are commonly used. Kingcoconut, a popular beverage from a special variety of *Cocos nucifera*, provides extra income when sold. Sap from the kitul palm (*Caryota urens*) either fresh or after fermentation is also a common beverage.

Herbal tea was completely neglected as a market product and only recently has it been rediscovered. *Aerva lanata, Cassia auriculata, Hemidesmus indicus, Aegle marmelos* are already sold as herbal drinks.

Spices and flavouring agents

21 species were recorded, *Cinnamomum zeylanicum, Capsicum annuum, Curcuma longa, Cymbopogon citratus, Elatteria cardamomum, Murraya koenigii, Myristica fragans, and Pandanus sp.* are commonly used for the preparation of curries. Some others such as *Syzygium aromaticum* or *Vanilla planifolia* are mainly sold. Plants like *Madhuca longifolia, Caryota urens* and *Cocos nucifera* would be a cheap source of sugar but their potential is not exploited in Sri Lanka today.

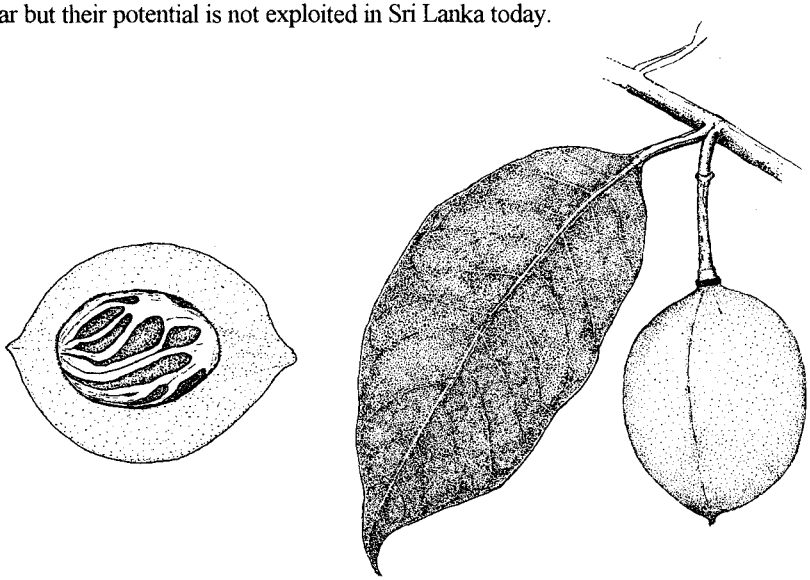


Figure 3.20. *Myristica fragans*, fruit in longitudinal section

Stimulants

6 species were recorded: *Caryota urens* and *Cocos nucifera* are used to prepare an alcoholic drink, *Areca catechu, Piper betle, Loxococcus repicola* and *Callicarpa tomentosa* are chewed.

Oils

11 species were recorded: *Acorus calamus, Aleurites molluccana, Anacardium occidentale, Canarium zeylanicum, Cocos nucifera, Cymbopogon citratus, Elais guinensis, Madhuca longifolia, Ricinus communis, Santalum album and Syzygium aromaticum.*

These oils are used for body care, hair treatments, medicine, cooking or illumination.

Figure 3.21. Castor *Ricinus communis*

3.6.4. Cash Crops

9 species including: coffee (*Coffea arabica*), tea (*Camellia sinesis*), cocoa (*Theobroma cacao*), cloves (*Syzygium aromaticum*), pepper (*Piper nigrum*), nutmeg (*Myristica fragrans*), cardamon (*Elettaria cardamomum*), cinnamon (*Cinnamomum zeylanicum*), and vanilla (*Vanilla planifolia*) can be called the cash crop component of the gewatta system, bringing monetary income for the farmer. These species have some characteristics in common: they are not important for subsistance production; they are easy to store and to transport; they are mainly for the export market (excluding coffee); prices are highly dependent on the world market situation and therefore they undergo constant fluctuations.

As long as they can be produced within the mixed cultivation of a traditional garden, ecological sustainable production is guaranteed. A shift, however, from mixed cropping to monocultural systems like tea- or spice plantations will certainly lead to a completely different situation, bringing high dependency and ecological problems for the farmers.

Table 3.3. Important food species and some of their multipurpose uses.
Abbreviations used as follows: F... fruits, V... vegetables, B... beverages, S... spices, M... medicine, St... stimulants, O...oils, R... plants with religious importance, C... plants used for cultural ceremonies, Ca... cash crops

Family	Species	F	V	B	S	M	St	O	R	C	Ca
MORACEAE	*Artocarpus heterophyllus*	X	X			X				X	
PALMAE	*Cocus nucifera*	X	X	X			X	X	X	X	
MUSACEAE	*Musa spp.*	X	X						X	X	
ARACEAE	*Xanthosoma sagittifolium*		X								
ARACEAE	*Alocasia cucullata*		X							X	
AMARANTHACEAE	*Alternanthera sessilis*		X			X					
AMARANTHACEAE	*Amaranthus oleraceus*		X								
AMARANTHACEAE	*Amaranthus paniculatus*		X								
AMARANTHACEAE	*Amaranthus tricolor*		X								
ARACEAE	*Amorphophallus paeoniifolius*		X			X					
MENISPERMACEAE	*Anamirta cocculus*		X			X					
MORACEAE	*Artocarpus altitis*		X								
MORACEAE	*Artocarpus incisus*		X								
MORACEAE	*Artocarpus nobilis*		X								
BASELLACEAE	*Basella alba*		X								
CUCURBITACEAE	*Benincasa hispida*		X			X					
LECYTHIDACEAE	*Caereya arborea*		X			X					
CANNACEAE	*Canna indica*		X							X	
PALMAE	*Caryota urens*		X	X		X	X				
UMBELLIFERAE	*Centella asiatica*		X			X					
ARACEAE	*Colocasia esculenta*		X							X	
CUCURBITACEAE	*Cucumis sativus*		X								
CUCURBITACEAE	*Cucurbita maxima*		X								
CUCURBITACEAE	*Cucurbita moschata*		X								
DIOSCOREACEAE	*Dioscorea alata*		X								
DIOSCOREACEAE	*Dioscorea penthaphylla*		X								
DIOSCOREACEAE	*Dioscorea spicata*		X								
LEGUMINOSAE	*Dolichos lablab*		X								
ASCLEPIADACEAE	*Dregea volubilis*		X			X					
EUPHORBIACEAE	*Drypetes sepiaria*		X								
GRAMINEAE	*Eleusine coracana*		X			X					
MYRTACEAE	*Eugenia sp.*		X								
MALVACEAE	*Hibiscus esculentus*		X	X							
CONVOLVULACEAE	*Ipomoea aquatica*		X								
CONVOLVULACEAE	*Ipomoea batatas*		X								
ARACEAE	*Lasia spinosa*		X			X					
PALMAE	*Loxococcus rupicola*		X				X				
CUCURBITACEAE	*Luffa acutangula*		X								
SOLANACEAE	*Lycopersicon esculentum*		X								
EUPHORBIACEAE	*Macaranga peltata*		X			X					

Family	Species	F	V	B	S	M	St	O	R	C	Ca
EUPHORBIACEAE	*Manihot esculenta*		X								
MARANTACEAE	*Maranta arundinacea*		X								
CUCURBITACEAE	*Momordica charantia*		X			X					
RUBIACEAE	*Morinda citrifolia*		X			X			X		
MORINGACEAE	*Moringa oleifera*		X			X					
RUBIACEAE	*Mussandra frondosa*		X								
LEGUMINOSAE	*Phaseolus vulgaris*		X								
LEGUMINOSAE	*Phaseolus lunatus*		X								
ARALIACEAE	*Polyscias balfouriana*		X								
LEGUMINOSAE	*Psophocarpus tetragonolobus*		X								
GRAMINEAE	*Saccharum officinarum*		X		X						
EUPHORBIACEAE	*Sauropus androgynus*		X								
CUCURBITACEAE	*Sechium edule*		X								
LEGUMINOSE	*Sesbania grandiflora*		X			X					
SOLANACEAE	*Solanum Xanthocarpum*		X								
SOLANACEAE	*Solanum indicum*		X			X					
SOLANACEAE	*Solanum melongena*		X			X					
MARANTACEAE	*Stachyphrynium zeylanicum*		X								
COMPOSITAE	*Synedrella nodiflora*		X								
COMBRETACEAE	*Terminalia catappa*		X								
CUCURBITACEAE	*Trichosanthes cucumerina*		X								
DIPTEROCARPACEAE	*Vateria copallifera*		X								
LEGUMINOSAE	*Vigna cylindrica*		X								
GRAMINEAE	*Zea mays*		X								
RUTACEAE	*Aegle marmelos*	X				X					
ANACARDIACEAE	*Anacardium occidentale*	X				X		X			
BROMELIACEAE	*Ananas comosus*	X				X					
ANNONACEAE	*Annona muricata*	X									
ANNONACEAE	*Annona reticulata*	X			X						
MORACEAE	*Artocarpus lackoocha*	X									
OIALIDACEAE	*Averrhoa carambola*	X				X					
OIALIDACEAE	*Averrhoa bilimbi*	X			X						
BURSERACEAE	*Canarium zeylanicum*	X				X		X			
CARICACEAE	*Carica papaya*	X									
RUTACEAE	*Citrus acidus*	X									
RUTACEAE	*Citrus aurantiifolia*	X				X					
RUTACEAE	*Citrus aurantium*	X				X					
RUTACEAE	*Citrus limon*	X									
RUTACEAE	*Citrus reticulata*	X									
RUTACEAE	*Citrus sinensis*	X				X					
CUCURBITACEAE	*Cucumis melo*	X									
CYCADACEAE	*Cycas circinalis*	X				X					
BOMBACEAE	*Durio zibethinus*	X									
ELAEOCARPACEAE	*Elaeocarpus serratus*	X									

Family	Species	F	V	B	S	M	St	O	R	C	Ca
RUTACEAE	*Feronia limonia*	X				X			X		
FLACOURTIACEAE	*Flacourtia inermis*	X									
FLACOURTIACEAE	*Flacourtia ramontchi*	X				X					
GUTIFFERAE	*Garcinia cambogia*	X			X	X					
GUTIFFERAE	*Garcinia mangostana*	X									
VERBENACEAE	*Lantana camara*	X									
SAPOTACEAE	*Madhuca longifolia*	X				X		X			
ANACARDIACEAE	*Mangifera indica*	X							X		
ANACARDIACEAE	*Mangifera zeylanica*	X							X		
SAPOTACEAE	*Manilkara zapota*	X									
SAPOTACEAE	*Mimusops elengi*	X				X					
SAPINDACEAE	*Nephelium lappaceum*	X									
SAPINDACEAE	*Nephelium longana*	X									
PASSIFLORACEAE	*Passiflora sp..*	X		X							
LAURACEAE	*Persea americana*	X									
EUPHORBIACEAE	*Phyllanthus debilis*	X				X					
SAPOTACEAE	*Pouteria campechiana*	X									
MYRTACEAE	*Psidium guajava*	X									
PUNICACEAE	*Punica granatum*	X				X					
SAPINDACEAE	*Schleichera oleosa*	X				X					
ANACARDIACEAE	*Spondias pinnata*	X									
MYRTACEAE	*Syzygium cumini*	X				X					
MYRTACEAE	*Syzygium jambos*	X									
MYRTACEAE	*Syzygium makul*	X									
MYRTACEAE	*Syzygium operculatum*	X									
LEGUMONISAE	*Tamarindus indica*	X			X	X					
STERCULIACEAE	*Theobroma cacao*	X		X	X						X

3.6.5. Plant Materials for Different Uses

Fodder

24 species used as fodder were documented, including mainly leaves and wild growing herbs and grasses. The habit of keeping livestock is not commonly found among Sinhalese farmers. Due to the Buddhist religion most of the farmers are more or less vegetarians and not interested in keeping animals which they would have to slaughter. This rules out even the breeding of chicken, which were rarely found in our survey. (from 111 farmers asked 39 kept livestock).

The leaves of *Mangifera indica, Persea americana, Gliricidia sepium, Leucaena leucocephala* and *Artocarpus heterophyllus, Musa spp.*, and different grasses like *Panicum maximum* are commonly used. *Caryota urens* is mainly fed to elephants. Farmers referred to nearly all of the wild growing grasses of the gewatta system as fodder.

Fibres
4 species were documented as being used: *Agave vera-cruz, Cocos nucifera, Caryota urens,* and *Coscinium fenestratum*

Gums
5 species were recorded to be known to the farmers: *Aegle marmelos, Anacardium occidentale, Carica papaya, Hevea brasiliensis* and *Vateria copallifera.*

Dyes
3 species were documented: *Acorus calamus, Artocarpus heterophyllus,* and *Michelia champaca*

Wrapping
9 species are commonly used for baskets, packages and wrapping of goods and food. "One of the many and varied facets of Sri Lanka is the traditional, indigenous forms of packing and vending used and practiced by vendors in this country. It is remarkable that they have persisted to such a high degree in spite of foreign domination for over three centuries. The small trader and the manner in which he carries on his business forms an integral part of our day to day living and his packaging or wrapping is influenced by his environment and the natural resources available" (Alles, 1982). *Allocasia macrorhiza, Colocasia esculenta, Canna indica, Carica papaya, Macaranga peltata, Musa spp.* are commonly used for wrapping.

Thatching
4 species were recorded. Palm leaves from *Cocos nucifera* and *Corypha umbraculifera,* a grass species *Imperata cylindrica,* and *Agrostisstachys hookeri* are mainly used for thatching. The traditional construction of houses using loam, bamboos, and other plant material is only found in remote areas with poor monetary income.

Insect repellants
5 species were documented: The seeds of *Gliricidia sepium* are called rat poison in Sinhala. They are used to protect stored goods from rats. *Azadiracta indica* produces an insecticide now commonly used and researched. *Tagetes erecta* is often planted in or near vegetable plots to work as a pesticide. *Ocimum sanctum* as well as resins collected in the forest (*Shorea cordifolia*) are burned and the smoke is said to keep insects away.

Ornamental plants
59 species were recorded. They do not represent all varieties because only the most common plants were included in our research. Most of these species are found close to the house and they have to be planted and maintained. Many ornamental plants have religious, cultural or other functions. *Anthurium sp.* for example is often sold for decorations or even for export. Different preferences of farmers can be observed depending on their education and life style. Gardens in Colombo or other town areas generally mainly consist of ornamental plants.

3.6.6. Plants Used for Religious and Cultural Purposes

Cultural ceremonies

Various species used mainly for decorations and offerings were documented. As stated earlier, village life is rich in ceremonies and festivals which need many special decorations and lavish cooking. In addition a number of plants are considered to be sacred and are therefore venerated.

Religious significance

Apart from these plants which are considered sacred, others are believed to have magical, supernatural powers and are similarly treated with veneration.

Table 3.4. Plants with religious and cultural importance

Family	Species	Religious	Cultural
PALMAE	*Areca catechu*	X	X
MELIACEAE	*Azadirachta indica*	X	X
PALMAE	*Cocus nucifera*	X	X
PALMAE	*Corypha umbraculifera*	X	X
GUTTIFERAE	*Mesua ferrea*	X	X
MUSACEAE	*Musa spp.*	X	X
PIPERACEAE	*Piper betle*	X	X
RUTACEAE	*Atalantia sp.*	X	
APOCYNACEAE	*Ervatamia divaricata*	X	
RUTACEAE	*Feronia limonia*	X	
MORACEAE	*Ficus benghalensis*	X	
MORACEAE	*Ficus religiosa*	X	
RUBIACEAE	*Ixora coccinea*	X	
ANACARDIACEAE	*Mangifera indica*	X	
ANACARDIACEAE	*Mangifera zeylanica*	X	
RUBIACEAE	*Morinda citrifolia*	X	
OLEACEAE	*Nyctanthes arbor-tristis*	X	
LABIATAE	*Ocimum sanctum*	X	
APOCYNACEAE	*Plumeria acuminata*	X	
APOCYNACEAE	*Plumeria alba*	X	
COMPOSITE	*Tagetes erecta*	X	
VERBENACEAE	*Vitex negundo*	X	
LEGUMINOSAE	*Abrus precatorius*		X
ARACEAE	*Alocasia cucullata*		X
ARACEAE	*Alocasia macrorrhizos*		X
ARACEAE	*Anthurium sp.*		X
MORACEAE	*Artocarpus heterophyllus*		X
BAMBUSACEAE	*Bambusa vulgaris*		X
CANNACEAE	*Canna indica*		X

Family	Species	Religious	Cultural
CANNACEAE	*Canna indica*		X
MELIACEAE	*Cedrellus toona*		X
ARACEAE	*Colocasia esculenta*		X
ZINGIBERACEAE	*Curcuma longa*		X
ZINGIBERACEAE	*Curcuma oligantha*		X
SYMPLOCAEAE	*Symplocos cochinchinensis*		X

3.6.7. Plants Used for the Structural Formation of the Garden

Some trees are specially planted for fencing, or for biological soil conservation. These species are placed on steep slopes, where their dense root system prevents soil erosion. Further on different pioneer species were documented. They need open spaces for germination. Some of them are important when a new garden is established in deforested areas. Tree species used as support for climbers like the pepper vine were likeweise included in the following table.

Table 3.5. Plants for structural uses Abbreviations used as follows: So... Soil conservation, Su... Support plant, P... pionier, F... fencing

Family	Species	So	Su	P	F
PALMAE	*Areca catechu*	X	X		X
BAMBUSACEAE	*Bambusa vulgaris*	X	X		X
LEGUMINOSAE	*Erythrina lithosperma*	X			X
LEGUMINOSAE	*Erythrina variegata*	X			X
LEGUMINOSAE	*Leucaena leucocephala*	X			X
EUPHORBIACEAE	*Manihot glaziovii*	X			X
LEGUMINOSAE	*Pongamia pinnata*	X			X
SAMBUCUACEAE	*Sambucus sambac*	X			X
MALVACEAE	*Thespesia populnea*	X			X
LEGUMINOSAE	*Gliricidia sepium*	X	X	X	
LEGUMINOSAE	*Albizia lebbeck*	X		X	
LEGUMINOSAE	*Albizia odoratissima*	X		X	
APOCYNACEAE	*Alstonia macrophylla*	X		X	
PROTEACEAE	*Grevillea robusta*	X	X		
AGAVACEAE	*Agave vera-cruz*	X			
SAPOTACEAE	*Madhuca longifolia*	X			
EUPHORBIACEAE	*Manihot esculenta*	X			
GRAMINEAE	*Vetiveria zizanioides*	X			
MORACEAE	*Artocarpus heterophyllus*				X
PALMAE	*Caryota urens*				X
EUPHORBIACEAE	*Sauropus androgynus*				X
BIGNONIACEAE	*Stereospermum personatum*				X
VERBENACEAE	*Vitex negundo*				X
RUTACEAE	*Acronychia pedunculata*			X	

Family	Species	So	Su	P	F
RUTACEAE	*Acronychia pedunculata*			X	
EUPHORBIACEAE	*Aleurites moluccana*			X	
VERBENACEAE	*Callicarpa tomentosa*			X	
ANNONACEAE	*Cananga odorata*			X	
LEGUMINOSAE	*Cassia fistula*			X	
EUPHORBIACEAE	*Macaranga peltata*			X	
LEGUMINOSAE	*Pterocarpus indicus*			X	
LEGUMINOSAE	*Samanea saman*			X	
DILLENIACEAE	*Schumacheria castaneifolia*			X	
MYRTACEAE	*Syzygium jambos*			X	
COMBRETACEAE	*Terminalia catappa*			X	
PALMAE	*Cocus nucifera*		X		

Out of the 480 most common species selected only 42 had no specific use and were addressed as wild plants. Most of them were tolerated and not declared as weeds. Sometimes farmers admitted to not being experienced enough to know how to use these plants. In their way of thinking this leaves the possibility open that any of these plants could be useful for something still unknown.

The following list shows some plants with no specific utilization

Lobelia nicotianifolia	*Leucas biflora*	*Solanum virginianum*
Dicranopteris linearis	*Acacia caesia*	*Melochia corcherifolia*
Commelina benghalensis	*Strychnos benthamii*	*Melochia umbellata*
Commelina diffusa	*Hiptage benghalensis*	*Symplocos racemosa*
Bidens pilosa	*Osbeckia aspera*	*Fleurya interrupta*
Conyza floribunda	*Maesa perottetiana*	*Stachytarpheta indica*
Emilia sonchifolia	*Peperomia pelucida*	*Stachytarpheta urticifolia*
Eupatorium odoratum	*Rivina humilis*	*Cissus trilobata*
Gynura sp.	*Petiveria alliaceae*	*Zingiber zylindricum.*
Microglossa zeylanica	*Zizyphus sp.*	*Flueggea sp.*
Tridax procumbens	*Knoxia zeylanica*	*Eragrostis tenella*
Wedelia trilobata	*Lepisanthes teraphylla*	*Cymbopogon sp.*
Mikania cordata	*Lepisanthes trichocarpa*	*Chrysopogon sp.*
Cyperus exaltatus	*Oplismenus compositus*	*Imperata cylindrica*
Cyrtococcum sp.	*Pennisetum sp.*	*Hyptis capitata*

3.6.8. Yields and Management of the *Gewatta* System

The following table (Table 3.6.) shows the detailed list of all the products harvested by the three different farm families in the gewatta system during the course of one year.

Table 3.6. Yields of three different gewatta systems in one year

	Arambegama	Welianga	Lewella
size of the gewatta	2025m²	16200m²	4050m²
number of species	113	57	105
harvested firewood	1288.5 kg/year	2025 kg/year	909.6 kg/year
harvested fruits	464 pieces	850 pieces	979 pieces
harvested coconuts	136 pieces	221 pieces	373 pieces
harvested vegetables	189.9 kg	634.8 kg	249.6 kg
harvested spices	4.7 kg	5.9 kg	12.45 kg
harvested cash crops	not recorded	2690 kg (cloves, pepper)	215.6 kg (pepper, cloves, coffee, cinnamom)
harvested fodder	no livestock	no livestock	6503 full baskets
collection of flower offerings for the temple	53 times	not recorded	60 times
collection of medicine	33 times	57 times	25 times

In general the *gewatta* system is characterized by a high level of product diversity and low average species yields. We can assume that much of the produced food in excess of family requirements is not harvested but decays in the garden or serves as food for wild animals. Most of the farmers do not apply any yield-increasing inputs such as fertilizers, pesticides or do not use improved varieties. The dense and forest-like vegetation includes a high number of young trees just entering the productive phase. Growth conditions for many trees are not optimal, as due to high plant density and excessive shading they attain only low yield levels. The *gewatta* system represents a method of cultivation described as a "live and let grow" attitude rather than modern crop management. The main goal of the farm family is not crop production but subsistance production.

Comparing the above listed figures it becomes obvious that the size of the *gewatta* system does not make a significant difference in subsistance production. On the contrary, the production of cash crops is dependent on the area and the intensity of cultivation. The *gewatta* in Welianga for example is low in species diversity due to the intensive cultivation of cloves and pepper but subsistance production is still provided. The *gewatta* in Arambegama is comparatively small but species diversity is maintained and subsistance production for a small family is provided. The amounts of fuel-wood harvested is even higher than in the other two gardens (being a retired school teacher,

the farmer was probably more accurate in his measurements of firewood than the other two farmers). The collections of flower offerings show the religious significance of the ornamental plants around the house. The relatively frequent collection of medicinal plants indicates that utilization of indigenous plant species to cure minor ailments is still common in the rural areas of Sri Lanka.

In general the output of the *gewatta* system can be measured in terms of products which provide for subsistence needs rather than by cash income. The profitability of a garden must therefore be considered from a different viewpoint to that of cash income. Including all by-products, such as medicine, fodder, plants used for body care, plants used for religious purposes etc., the productivity of an average garden is high. If one converted the subsistence needs sustained from the *gewatta* into monetary values the entire income would be an impressive figure. Further research on this topic could offer an interesting insight into the true quality of life enjoyed by the average Sri Lankan farmer.

The subsistence production of an average homegarden can furthermore be measured by outside expenditure on foodstuff and other articles. The average situation can be described as follows: Sugar, salt, dry fish, flour, tea, milkpowder, rice and some vegetables and chilli are mostly bought from outside. These requirements are simple and will not burden the family income too much. The *gewatta* provides most of the essential needs and foodstuffs for everyday life. The changing lifestyle however, will bring much more monetary expenditure on articles such as TVs, cars, refrigerators, books, clothes, and other items. These requirements cannot be met with the surplus production from the *gewatta* system as prices are too low and marketing skills are not developed to an optimum.

Management

The *gewatta* system is characterised by minimal input of fossil energy, while capital intensive investments are low. The most labour is used for harvesting the crops and plants grown on the farm land. Maintenance, planting and weeding are negligible as they consume a small amount of time. The most time-consuming crops are tea, cloves, pepper, coconut, kitul, different fruits and vegetables in descending order.

The amount of hired labour used is dependent on the social status of the family. In the area of Kandy, where off farm income is easy to obtain, hired labour is more common than in other areas. McConell states :

> Paradoxically, although most of these farms have a large surplus of family labour, hired labour is by far the largest cost item. The other input costs are relatively insignificant both in absolute terms and in relation to the value of production. Hired labour accounts for 87.2 percent of all costs. Use of such conventional inputs as pesticides, fertilizers, purchased seeds and plants is minimal and is limited to those farms having certain crops such as tea, paddy and vegetables (MCCONELL 1992, 59).

In general, fixed costs are minimal in the *gewatta* system. For processing and maintaining crops no equipment other than hand tools are necessary. Young plants and seedlings are mostly found in the garden itself or they are exchanged with

neighbours. Investments are generally undertaken for the household rather than for the garden. The only external input is found in the case of fertilizer application. Tea, pepper, bananas, coconuts, coffee, cloves and vegetables are treated with fertilizer. The use of pesticides on cash crops is a fairly recent innovation. The Sinhala word for pesticides "*behet*" translates as medicine and indicates the intention of the farmer, he wants to apply medicine to plants rather than poison insects or fungi. In the gewatta system, however, pesticides or herbicides are still uncommon.

Table 3.7. Input of labour end energy per year

Input	Arambegama	Welianga	Lewella
chemical fertilizer		8 kg	
labour	father, two hours/ day	5-10 labourers, occassionly	mother, 5 hours/day
waste	ash, compost 2-3 kg/day	ash, left over food 1kg/day	ash, food, goats manure, 3kg/day
livestock			2 goats
toilet	made of bricks, leaks into the garden	made of concrete, rebuilt when filled	made of bricks, leads into the garden
water	well for bathing does not benefit the garden	bathroom water runs into the paddy field	bathroom water runs through bamboo pipes into the garden

3.7. Structural Features of the *Gewatta* System

3.7.1. Introduction

> *The structure of vegetation is defined by three components: the vertical arrangement of species, i.e. the stratification of the vegetation; the horizontal arrangement of species; i.e. the spatial distribution of individuals; and, finally, the abundance of each species (KERSHAW 1973, 5).*

Structural elements are closely linked with functional processes. Therefore an important part of our work was dedicated to the investigation of the structural features of the *gewatta* system. It was our objective to compare the results and findings of the *gewatta* system with the forest ecosystem investigated. Udawattekele forest was used as reference for a forest ecosystem.

3.7.2. An Investigation of the Structure of one Specific *Gewatta*

In one *gewatta* (Lewella, near Kandy) the family gave us permission to mark all the trees so that we could study structure and species composition in detail. The results were impressive, we counted 372 individual woody perennials in an area of 4000m².

The canopy (between 20-30m) and the upper tree level (15-19m) were dominated by *Cocos nucifera, Artocarpus heretophyllus* and *Areca catechu.* They influence growth conditions such as the amount of light penetration, the exposure to wind, moisture, humidity and temperature within the gewatta system. The lower-middle level (10-14m) is characterized by younger or suppressed trees, if space and light is available they will grow up to the higher canopy levels. Species composition of the two lower levels is quite different and dominated by shade tolerant shrub species, vines and small trees. The ground level is highly heterogenous, close to the house ornamental plants are grown, throughout the *gewatta* different wild grasses and fodder species occur, vegetables are planted where light conditions allow their growth. The following table (3.8.) shows the distribution of species and individuals in different height classes in the *gewatta* of Lewella (Kandy).

Table 3.8. Distribution of species and individuals in different height classes

Height class	Sp.	Ind.	Dominant Species
20m - 30m	7	39	*Cocos nucifera, Artocarpus heterophyllus, Areca catechu*
15m - 19m	11	19	*Areca catechu, Cocos nucifera, Mangifera indica*
10m - 14m	8	22	*Areca catechu, Persea american,*
5m - 9m	20	66	*Gliricidia sepium, Coffea arabica, Syzygium aromaticum*
climbers	10	108	*Piper nigrum, Diaschorea sp.*
1m - 4m	34	266	*Coffea arabica*
0m - 1m	81	----	ornamental plants, vegetables, fodder, yams, spices

The relationship between the different tree levels are established downwards and upwards.

> The amount of sunlight and, to a lesser extent, the amount of wind at any canopy level is influenced by the cumulative position-space-density properties of higher canopies. But the reverse is not true: lower-level canopies will not exercise light and wind protection on higher level canopies. [...] However, the moisture, humidity and temperature factors have effects in both directions. The nature of the upper-level canopies affects the growth conditions downwards to lower-level mixes and the lower-level canopies have an upward effect on the growth conditions for the higher-level mixes (McConnell, 1992,6).

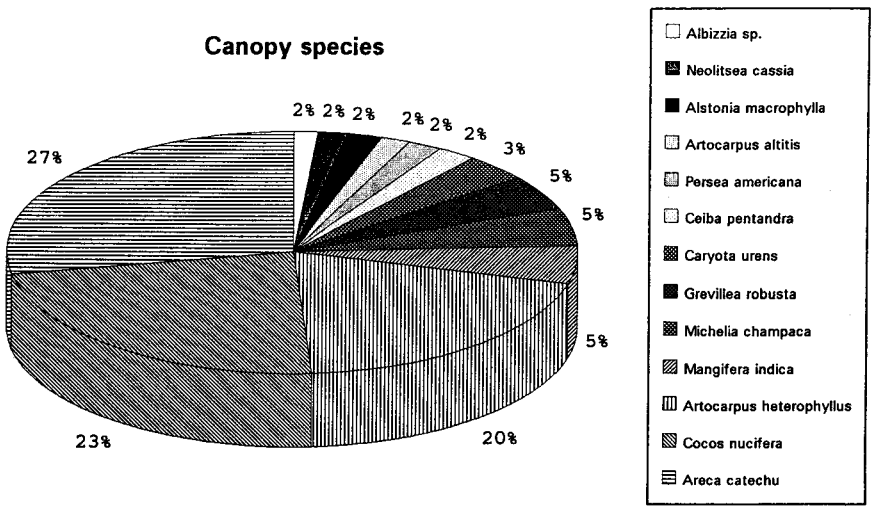
After having considered the structural features of one specific *gewatta* we will move to the more general aspects.

3.7.3. General Structural Features of the *Gewatta* System

A total of 3412 individual trees taller than 1m were recorded in 80 plots covering an area of 2600m². Out of these, 541 individual trees (43 species) form the canopy layer of a *gewatta*. These trees reach a height of 20m to 35m and cover about 60-80 percent of the plot surface with their expansive crowns.

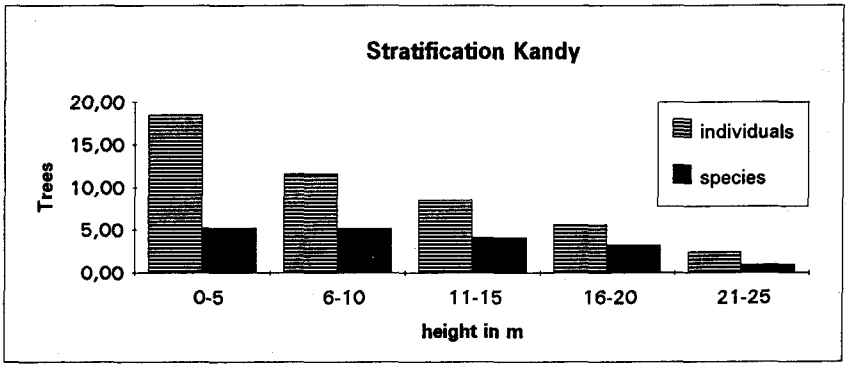
Areca catechu (154 trees, 4.6%), *Cocos nucifera* (126 trees, 3.8%) and *Artocarpus heterophyllus* (109 trees, 3.2%) dominate the upper layer of the *gewatta* whereas *Mangifera indica*, *Michelia champaca*, *Grevillea robusta* and *Caryota urens* constitute a smaller proportion of the canopy. An additional 36 species, which occurred only randomly, comprised the remaining percentage of the canopy.

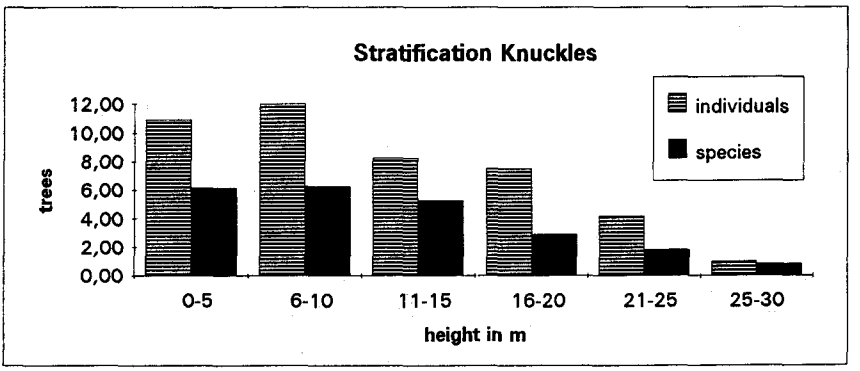
Figure 3.22. Distribution of canopy species

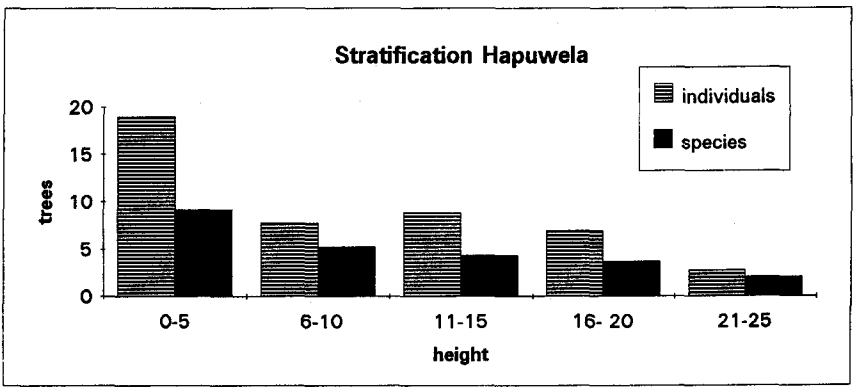


The typical patterns of stratification found in the different areas can be seen in the following figures from the areas of Kandy, Knuckles and Hapuwela.

Figure 3.23. Stratification of tree species and individuals in different areas







The lower canopy levels ranged between 1m and 20 m in height. A total of 2871 individual trees were recorded within the lower canopy levels, which build the main component of a *gewatta*. The lower canopy levels include upper-middle (15-19m), lower-middle (10-14m) and lower level (1-9m) trees. The vertical stratification of a *gewatta* is complex and the different layers are not easily distinguishable. It must be remembered that once a tree outgrows the height which constitutes the lower levels (1-20m) it is included within the canopy layer (20 to 35m) as defined above.

The lowest level between 1m to 10m bears the highest number of individual trees and species. It consists of shrubs, small trees or young trees, seedlings and climbers. From 10 to 15m the number of individuals and species slowly diminishes. The next layer, between 15 and 20m, slowly transgresses into the canopy layer and the number of individual trees and species decreases further. Within the lower canopy the proportion of individuals to species is 2 to 1.

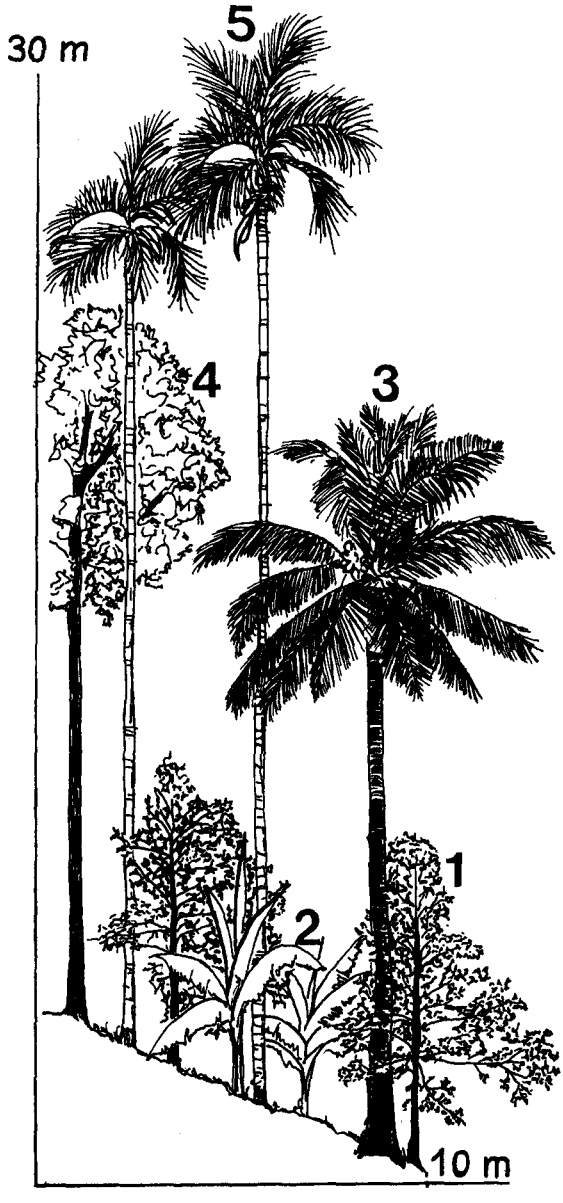
A more distinct picture of the complex structure of the *gewatta* system can be obtained with profile diagrams. Not only the height of the trees but also the size of their crowns is a crucial factor. Coconut palms (*Cocos nucifera*), jak trees (*Artocarpus heterophyllus*), timber trees, different fruits trees like mango (*Mangifera indica*) or avocado (*Persea americana*) for example, have expanding crowns, whereas the betel nut palm (*Areca catechu*) only occupies a small area with its crown.

The specific structural features presented graphically in the profile diagrams (Figure 3.24., 3.25.) are responsible for the growth conditions and productivity of the *gewatta* system. These conditions arise from within the *gewatta* system itself and are not imposed from without as in monocultural farm systems.

> In a pure-stand rubber system, external management inputs tend to be paramount. Most of the factors affecting growth of the crop, such as synthetic fertilizers, pesticides, herbicides, crop hygiene programmes, tapping frequency and tapping method, are external. [...] Forest-garden systems in contrast, generally have few conventional crop inputs such as synthetic fertilizers and pesticides, so the impact on crop growth and productivity from external factors is practically non-existent, management excepted (McConell,1992, 16).

The internal factors influencing growth and productivity are strongly connected to structural features. They can be manipulated by management decisions like felling mature trees with expanding crowns, or planting and maintaining certain species at an appropriate place in the garden. The efficient management of a *gewatta* is therefore very complex and we can assume that any alterations to one species may indirectly affect most of the other species.

Figure 3.24. Profile diagram, Arambegama



1. *Syzygium aromaticum*
2. *Musa spp.*
3. *Cocos nucifera*
4. *Alstonia macrophylla*
5. *Areca catechu*

Figure 3. 25. Profile diagram, Pilimatalawe

1. *Mangifera indica*
2. *Areca catechu*
3. *Cocos nucifera*
4. *Coffea arabica*
5. *Syzygium aromaticum*
6. *Gliricidia* with *Piper nigrum*

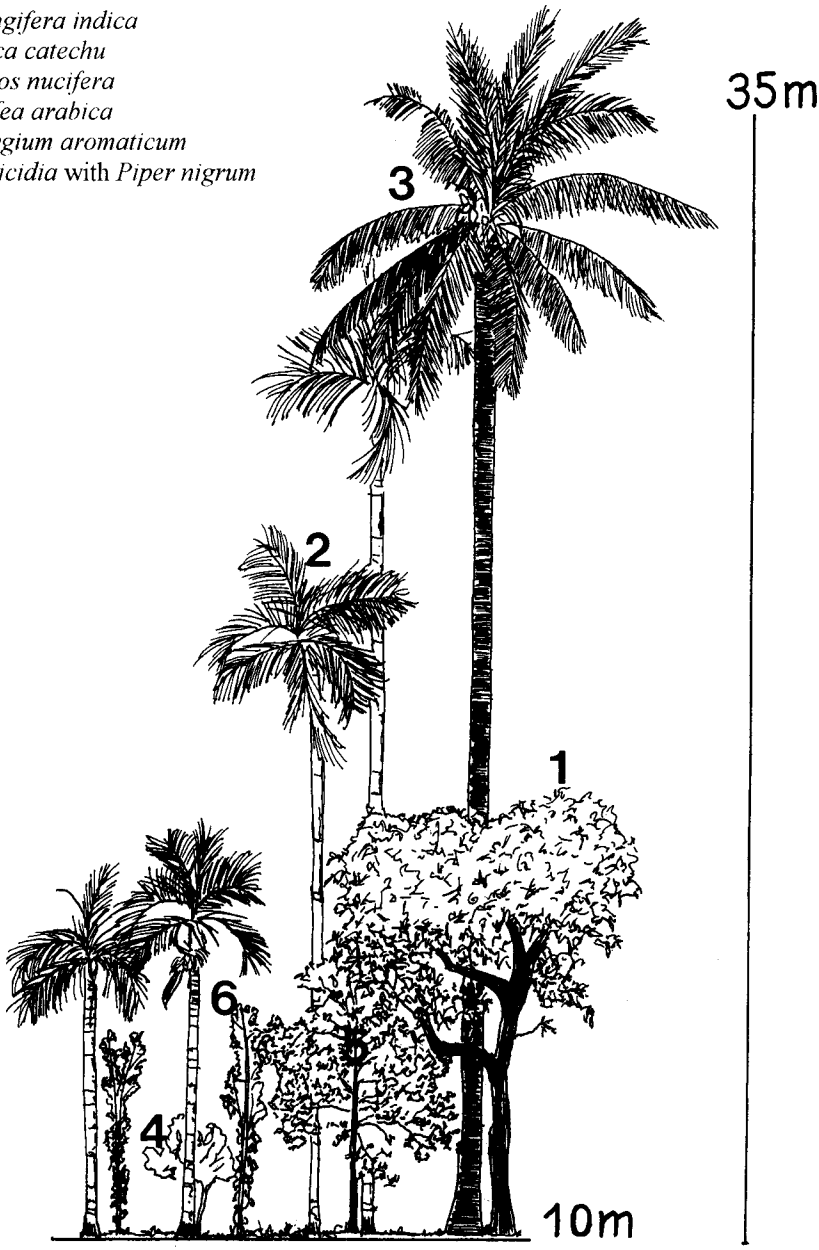
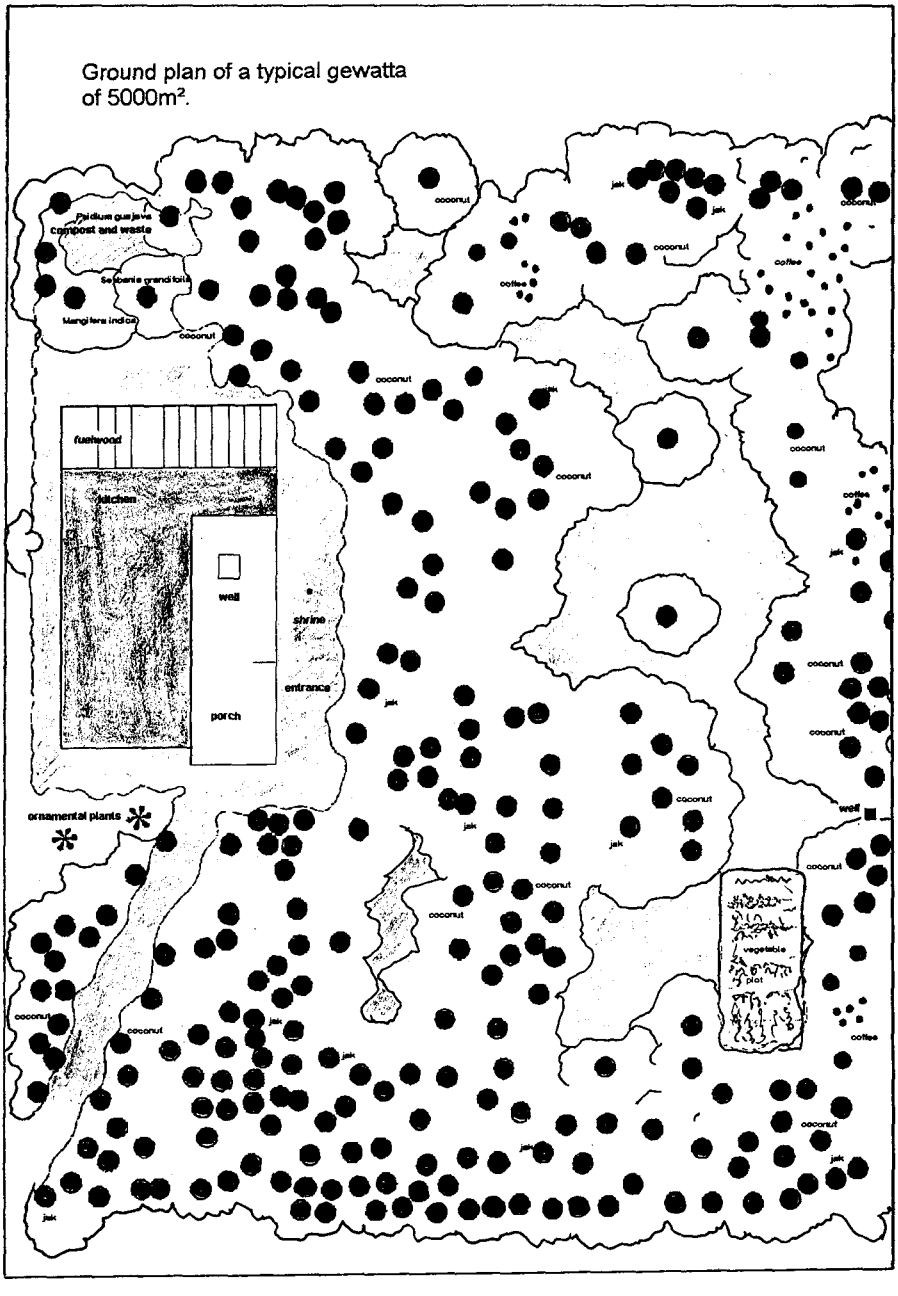


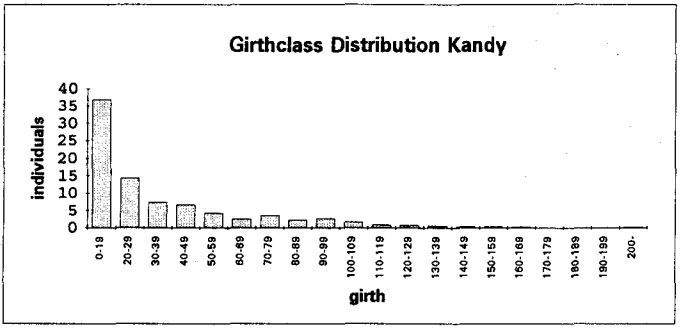
Figure 3.26. Ground plan of a traditional *gewatta* of 5000 m²

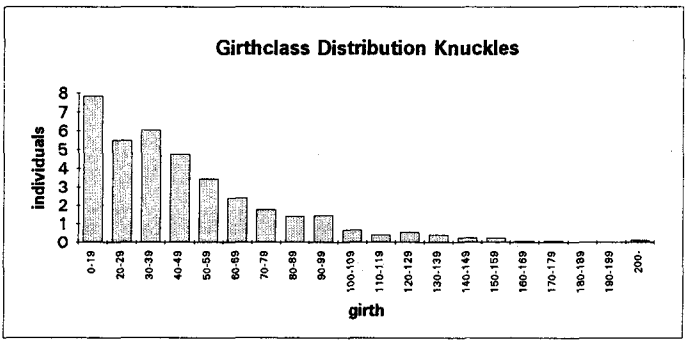


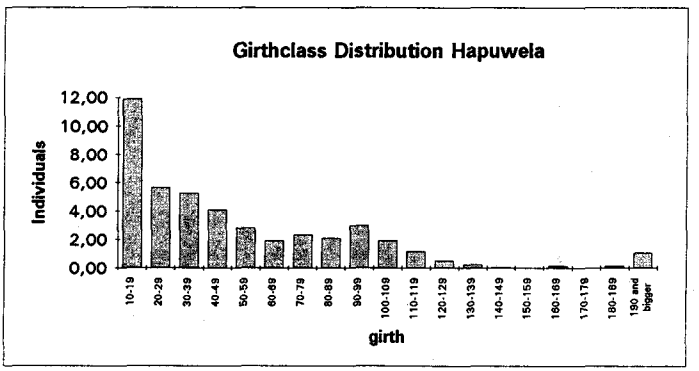
3.7.4. Girth Class Distribution

The distribution of different girth classes within the *gewatta* system gives a detailed picture of the structural characteristics. The next figure shows the girth class distribution of different areas investigated.

Figure 3.27. Girth class distribution of different areas







Since girth measurement is related to the age of a tree, girth class distribution provides information on how even-aged or uneven-aged a stand is. Furthermore it allows some speculation about stand history, management and site qualities. High frequency in the smaller girth class signifies a high regeneration rate and favourable conditions for young tree seedlings. A relatively even distribution over all girth size classes is characteristic of an uneven-aged stand where younger trees will gradually replace the older generation.

At this point we will not elaborate on the specific differences between the areas investigated but instead, develop a general picture.

The majority of individual trees in the investigated plots have a girth between 10 and 50cm. A reduced number of trees is found between 50cm and 100cm girth. The third group with only a small number of trees consists of trees bigger than 100cm girth, up to a maximium of about 200cm. The absence of trees with a girth over 200cm in the *gewatta* can be explained with human impact. Mature trees with expanding crowns are usually harvested.

The relatively even distribution of diameter size signifies that the regeneration rate is high and young trees continuously grow into the higher canopy layers. Constant management is one factor that keeps the *gewatta* system in a comparably young successional state. The age of a stand is dominated by younger plants. According to our observations farmers will fell fruit trees when their productivity is decreasing. Also the so called cash crop component of a *gewatta* consists of smaller trees or shrubs such as coffee, (*Coffea arabica),* cloves *(Syzygium aromaticum), Gliricidia sepium,* cinnamon *(Cinnamomum zeylanicum) and* cocoa *(Theobroma cacao).* Coffee (*Coffea arabica)* and *Gliricidia sepium* can dominate the lower level of a garden completely and thereby contribute much to high numbers of individuals in the girth class between 10 and 20cm. These species are planted and maintained by the farm family. *Gliricidia sepium* is mainly used as a support plant for pepper vines (*Piper nigrum*). The high frequency of trees in the lowest girth class therefore signifies intensified management and a high percentage of cash crops.

Usually all species are represented in all girth classes from 10cm to 50cm, while only jak (*Artocarpus heterophyllus*), coconut (*Cocos nucifera*), kitul palm (*Caryota urens*) and some timber trees like *Michelia champaca, Melia dubia* or *Alstonia macrophylla* attain maximum girth size between 100 and 200 cm.

Typical medium sized trees with a girth between 30 and 70 cm are *Areca catechu* and *Thespesia populnea.*

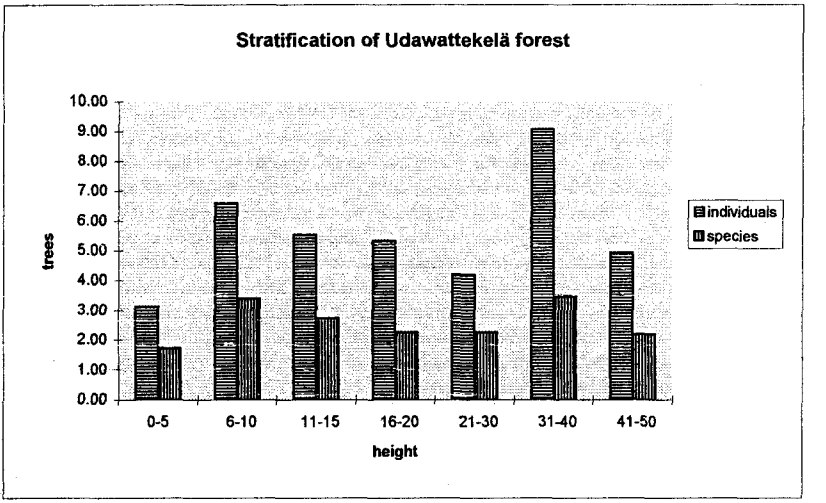
Mangifera indica, Persea americana and *Myrsitica fragrans* usually belong to the medium sized trees, they can grow bigger when they are allowed to but usually they are felled when they reach a certain size and age. We were able to find some singular specimens with a girth greater than 100cm.

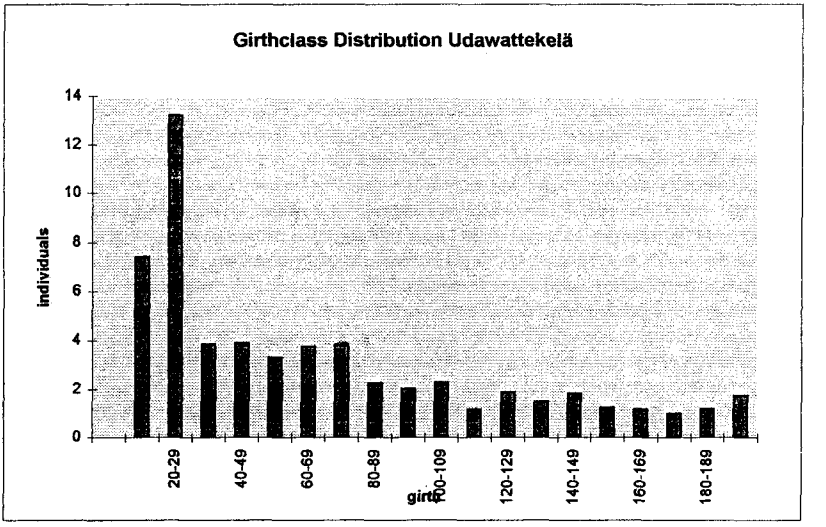
3.7.5. A Comparison of the *Gewatta* System and the *Udawattekelä* Forest

To compare the structural features of the *gewatta* system to a forest ecosystem we used *Udawattekelä*, a tropical lowland rainforest located north of Kandy town.

Girth class distribution and the vertical stratification of the forest can be seen in the following figure .

Figure 3.28. Structural features of Udawattekelä forest





The upper canopy of the forest reaches 45m and more, *Alstonia macrophylla, Artocarpus heterophyllus, Michelia champaca* and *Filicium decipiens* dominate the canopy, whereas *Nothopegia beddomei, Terminalia belerica* and *Achronychia pedunculate* are mainly found in the lower levels of the forest. *Swietenia macrophylla* can be observed in all layers between 5m and 30m height. The highest number of individuals was measured to be between 31 and 40m. It was found that trees taller than 30m are more frequent in the forest than in the *gewatta* system.

The distribution of height classes recorded in the *gewatta* system is similar to that of the forest only up to a tree height of 35m. The *gewatta* system does not have a high canopy layer above 30m. Trees taller than 35m do not occur in the gardens due to human impact and the lower nutrient levels of the soil.

The vertical stratification of the *gewatta* system is considerably influenced by the harvesting of mature trees for timber as practised by farmers. The expansive crowns of very tall trees would dominate the structural features of a garden. They would compete with other canopy species of a lesser height. The amount of shade would also effect the growth performance of other species in a negative way. Therefore tall trees are obviously missing due to continuous felling. Another explanation might be that the lower nutrient content of soils in the *gewatta* system does not facilitate tall trees and maximal growth. A similar coherence between tree size and nutrient level was discussed by Yamacura (YAMACURA 1990).

Another consideration is the different species composition of the *gewatta* and the forest system. The upper canopy trees like *Cocos nucifera* or *Areca catechu* are probably limited in their size as they have shallow roots. *Artocarpus heterophyllus* as well as some timber trees like *Michelia champaca, Alstonia macrophylla* and *Swietenia macrophylla* could grow to a bigger size but as mentioned above they are usually cut for timber when they have reached a certain size.

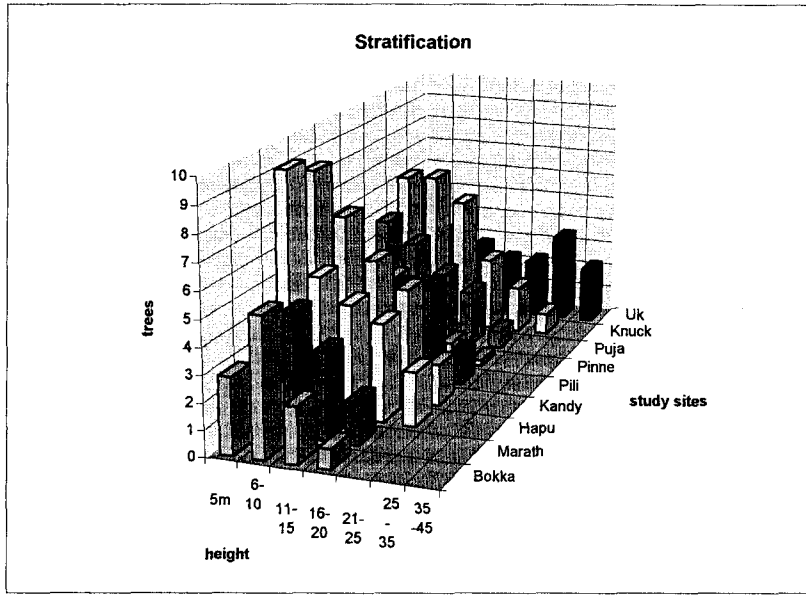
In contrast to the *gewatta* system, trees taller than 30m form the dominant layer in the forest site with the highest number of individuals occurring. Depending on the geographic conditions and altitude, as well as nutrient status, forest species will grow up to their maximal height. Excessive shading and a poor undergrowth are other characteristics of the forest with a high and dense canopy layer.

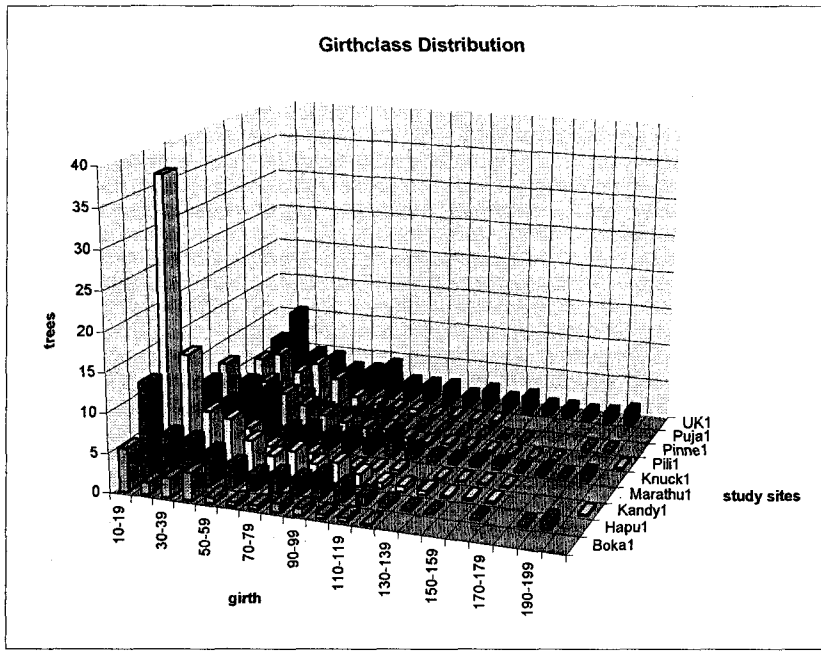
Similar findings are shown in the girth class distribution of the forest system. Trees with a girth greater than 150cm were not commonly found in the *gewatta* system, whereas the forest showed an increasing number of trees in higher girth classes. This distribution can also be explained by the lack of human impact within the forest.

The high frequency of trees between 19 and 29cm girth signifies abundant regeneration and describes a condition favourable to the continued existance of the stand.

The following figure shows a comparison of the structural features of the different sites investigated. The number of trees is related to plot size ($100m^2$).

Figure 3.29. Comparison of the structural features of the different sites investigated





3.7.6. Density and Basal Area

Density and basal area give a more detailed description of plant population. Basal area is used to calculate timber volume and it can be used as a measure of species dominance. In order to produce comparable data the establishment of plots was neccesary. The following table gives an overview on how the different plots of the study sites were characterized. Plot size varied between 100m² and 400m² for garden sites and up to 1250m² for the forest respectively.

Site 6 (Deniaya and Pitekele) could not be investigated using plots because the structural features of the gardens found there had been completely changed. Most of the land had been converted into tea plantations and the *gewatta* was restricted to a small belt of trees around the house. Therefore plots could not be established.

Table 3.9. Plots and basal area of the different study sites
PL...Number of plots, Ba...basal area

location	PL	total plot area	trees total	trees per 100m²	ba total	ba/100m²
Kandy	12	8050m²	1008	12.4	174933cm²	2173cm²
Pilimatalawe	14	4500m²	588	13.0	141351cm²	3141cm²
Marathugoda	6	900m²	103	11.4	35735cm²	3970cm²
Pinewela	14	1900m²	222	11.7	50049cm²	3263cm²
Pujapitiya	6	1100m²	174	15.7	29551cm²	2686cm²
Bokkawela	8	900m²	148	16.4	25560cm²	2840cm²
Knuckles	6	2400m²	306	12.75	101666cm²	4236cm²
Hapuwela	7	2600m²	303	11.7	137545cm²	5290cm²
Udawattekele Forest	15	14500m²	560	3.8	356359cm²	3058cm²

The variation among the investigated farms with respect to the number of plants per 100m² was low. The overall mean of 13 individual woody perennials per 100m² is extremely high, particularly when the size of individual plant species like jak (*Artocarpus heterophyllus*), or coconut (*Cocos nucifera*) is considered.

The high density of trees, between 11000 and 16000 trees per hectare, can be seen as one of the most important structural features of the traditional *gewatta* system. Because of the methodology used we must take into consideration that the house and the compound around the house will reduce the average number of trees per area. But even if we reduce the average number of trees by 20-30% we will still get a density of 900 to 1200 trees per ha or 420 trees per acre.

These findings are not comparable to the results of D.J. McConell. His study yielded an average density of 187 trees per acre (450/ha), though he admitted that the data tends to underestimate true plant population by 25 to 30 percent (MCCONELL 1992, 21). The different result can be explained by the fact that most of the farms investigated by McConell were tea farms, where the amount of shading must be reduced. In traditional *gewatta* systems tea and other cash crops do not dominate structural features and the crown cover mostly exceeds 70%.

The findings of Perera and Rajapakse (PERERA 1991, 271), however, show similar results. This study reports a density of 500 to 1500 trees per hectare.

In our findings the overall mean of 3450cm² basal area per 100m² is similar to the forest system although tree density is much higher. These findings can provide some information about the *gewatta* system with its high number of young and growing trees and some singular big trees.

Summarising we can say that the plant population density of a traditional *gewatta* is extremely high and even exceeds forest ecosystems. The high density of individuals and tree species found within the limited area of an average *gewatta* can be explained by the successional character of the *gewatta* system.

The forest site with fewer but more mature trees builds up a similar basal area with a much lower density of trees (380/ha). An increasing number of big and old trees with large trunks contributes to the high value of basal area (3058cm²).

3.7.7. Dominant Tree Species

The physiognomy of the investigated *gewatta* systems was more or less forest-like. Due to the complex appearance it was difficult to trace the dominating components of a garden. Therefore we decided to use the Important Value Index to indicate dominance. The Important Value Index or IVI is calculated as the sum of relative density, frequency and basal area. It gives an indication of the importance of each species. Usually this method is applied in forestry but we have adopted the methodology for the *gewatta* system. The established plots formed a comparable basis for the calculation of the IVI.

The following table shows the IVI index for the most important species of the different study sites (Mean Value of all sites, Kandy, Pilimatalawe, Marathugoda, Pinewela, Pujapitiya, Bokkawela, Knuckles, Hapuwela, Udawattekelä Forest)

The calculated mean value gives an overall picture of the most important tree species.

Table 3.10. IVI Index MV....Mean value of all sites

Tree species	MV.	Kan	Pil	Mar	Pine	Puja	Bok	Kn	Hap	UK
Areca catechu	109	96	104	147	96	122	100	108	101	-
Artocarpus heterophyllus	99	102	96	115	91	83	75	114	114	110
Caryota urens	49	66	24	36	8	36	53	91	83	53
Cocos nucifera	99	113	113	91	122	47	91	77	136	-
Coffea arabica	45	108	63	18	53	-	42	52	28	-
Gliricidia sepium	60	84	80	-	64	43	99	38	70	-
Mangifera indica	53	65	47	37	7	40	92	60	81	42
Michelia champaca	49	73	62	17	24	16	95	79	28	79
Myristica fragrans	34	35	38	77	-	95	30	-	-	-
Neolitsea cassia	28	26	14	17	-	17	13	89	47	33
Persea americana	44	62	57	56	41	37	61	-	43	-
Swietenia macrophylla	21	27	19	33	68	19	-	-	-	126
Syzygium aromaticum	67	54	95	82	68	119	78	17	28	-
Thespesia populnes	13	16	-	-	7	-	-	-	81	-

Areca catechu shows the highest value. It is interesting to notice that this more detailed investigation including frequency and density obviously brings new results. Only from observation and appearance of the *gewatta* the betel nut palm (*Areca catechu*) would seem to be a common but not dominating feature of the gardens. The stems of this palm usually do not exceed 60cm girth, yet the rather small dimension of the crown allows a high density of palms within a small area. The importance of this plant lies in its deeply rooted cultural significance. Since ancient times the nuts of the palms have been used as a means of trading, and the tree is part of many important ceremonies. Another reason for the dominance of this tree is the widely spread habit of chewing betel. Especially in rural areas a high percentage of the population regularly uses the "betel bite". The stimulating effect and the relief it offers from hunger and tiredness makes it very popular. The tree is rarely planted but germinates by wild propagation. Following *Areca catechu*, *Artocarpus heterophyllus* and *Cocos nucifera* are equally important. The following 12 species with decending IVI are distributed differently according to the geographic conditions and social as well as economic factors. The variations among the different areas investigated will be discussed in the following paragraphs.

3.8. Comparison of the Different Areas Investigated

The following table (3.11.) gives a short characterization of the different study sites and the *gewatta* systems found there.

Table 3.11. Geographic features and species diversity of the *gewatta* system in the different study sites.

Abreviations used in the table are as follows: A... number of surveyed gardens; Size... the average size of the investigated *gewatta*; E...elevation; Rain...average rainfall of the area in mm/year; L... the percentage land use covered by the *gewatta* system in the area (source, SURVEY DEPARTMENT 1988); Slope...the average inclination found in the gardens in percentage; P... the average number of species documented.

Location	A	Size	E	Rain	L	Slope	P
Site 1 Kandy District	51	3000m2	490-600m	2188	24.4	1-20	50
Site 2 Kegalle District	15	4000m²	90-120m	-	32.0	2-5	64
Site 3 Matale District	24	5300m²	270-520m	2012	12.8	1-5	52
Site 4 Knuckles Range	23	5500m²	300-640m	2622	-	10-20	52
Site 5 Nuwara Eliya District	12	2200m²	640m	1536	7.0	10-20	48
Site 6 Galle District	14	3100m²	300-450m	4054	28.9	10-20	52
Site 6 Ratnapura D.	19	8400m²	370m	5006	17.3	10-20	53

For the comparison of the different sites we used the results of three different approaches in our investigations. Plant inventory, plot investigations (plot investigation could not be used for Site 6 because the structural components were already changed and we could not apply our method of establishing plots) and a farmers survey.

The combination of these three methods showed some new results. A classification of the different types of *gewattas* according to structural, floristic or management components was worked out. We divided the different study sites and the types of *gewattas* found there into three main groups.

Group 1. Traditional Kandyan Forest Garden
Group 2. Smallholder *gewatta* of remote areas
Group 3. Intensified *gewatta*

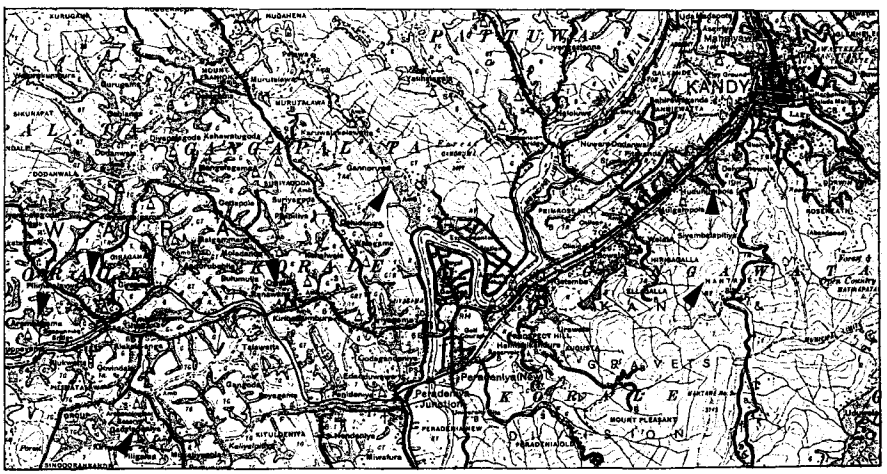
3.8.1. Group 1. Traditional Kandyan Forest Garden

Location: Kandy Area, Kegalle, Matale (Site 1,2,3)

SITE 1: Kandy District: Kandy town area, Pilimatalawa (7°16'N, 80°24'E) Arambegama, Kiribathkumbura, Marathugoda.

Kandy District: The overall administration of the district is controlled by the government agent based in Kandy town. The town provides a lot of services such as hospitals, schools, a university, offices and a tourist industry. The main agricultural land uses are paddy cultivation, homegardens, tea and annual crops such as tobacco and vegetables. The *gewattas* surveyed were situated adjacent to the paddy fields.

The maps used in the following paragraph are based on the Ceylon one inch map



The 13 gardens surveyed were located along the Kandy-Colombo road. Most of them measured one acre[1]. Apart from two sites the *gewattas* were more than 50 years old, ranging between 100 and 300 years in age. The land had been inherited from previous generations. An average family had 5.6 members. With the exclusion of two farmers all

[1] 1 acre is 4050m²

the families earned off-farm income from different professions (teacher, civil servant, doctor,...).

Pilimatalawe: The 27 gardens investigated lay west of Kandy interior on boths sides of the main Kandy-Colombo road. Kiribathkumbura, Arambegama, and Pilimatalwe were the main villages investigated. Most of the gardens measured one acre. The average age was 50 years, ranging from 12 to more than 200 years. The average size of one farm family was 7.7. All families had off farm income and were not mainly dependent on agricultural activities for their living. Most of the people sold their products in Pilimatalawe town.

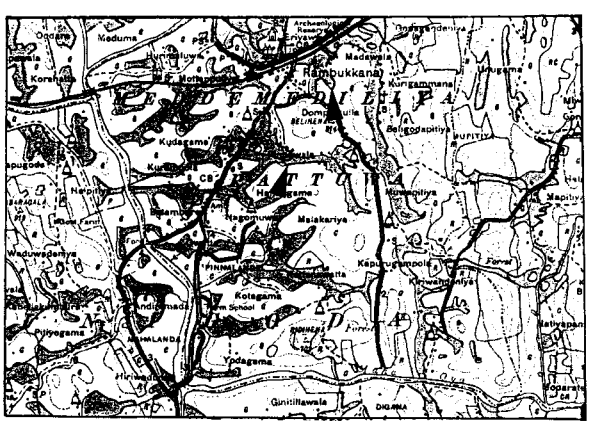
Hantana, Suduhumpola Patanawatte: These 5 gardens were a special case because they are new settlements, established on a former patana grassland. The land owned by a temple was distributed to poor families. The extension was smaller than 1000m² and the *gewattas* were between 6 and 20 years old. Most families had an average of 10.6 members. For them the firewood supply from the garden was not sufficient and they had to purchase it. In all cases the *gewatta* system did not bring any monetary income. The main problem mentioned was soil erosion which was difficult to control on the rather steep slopes with 15 to 30% inclination.

Marathugoda: 6 gardens were investigated, not larger than one acre and between 20 and 100 years old. All families earned off farm income.

SITE 2: Kegalle District: Pinnewela (7°19'N, 80°24'E), Rambukkana

Kegalle District: Roads and infrastructure were well developed. Topographic and climatic conditions were suitable for the *gewatta* system. The area was rather densely populated and people were not mainly dependent on agricultural activities for their income.

Pinnewela: 15 gardens were surveyed. Most of these were smaller than one acre. 9 of the 15 surveyed gardens were older than 50 years. Average family size was documented with 5.7 members.



SITE 3: Matale District: Bokkawela (7°24`N, 80°33`E), Galagerdera

Pujapitiya: 15 gardens, mostly smaller than 1 acre, were investigated. Family size was documented with 5.5 members on average. The average age ranged from 20 to 100 years. Apart from one family all had other sources of income from outside jobs.

Bokkawela: 9 gardens were surveyed, mostly larger than 1 acre and older than 20 years. 4.9 family members were documented on average. All families had off farm income.

General features of the traditional Kandyan forest gardens

- **Average size**: 4100m^2
- **Age**: between 50 and 100 years
- **Family size**: 6.1
- **Management intensity**: 10 hours per week, 10% used hired labour
- **Fertilizer application**: 31.4% used fertilizer especially for coffee, pepper, cloves, banana and anthurium.
- **Off farm income**: 91% obtained off farm income from various jobs.
- **Market access**: 72% sold the garden products to a trader who came regularly to collect any surplus production. All families had some income from the garden.
- **Firewood supply**: for any garden bigger than 2000m^2 the firewood supply was sufficient.
- **Animal component**: 1% had an animal component (cattle, chicken or goats) included.
- **Structural features**: The forest-like vertical stratification was dominated by woody perennials of different age and size. Average density of trees was very high, recorded as 13400 trees per hectare, average basal area was 3012 cm^2. High density of trees and comparatively lower values of basal area characterized a high number of young trees and shrubs and a shift towards spice production within the areas of Kandy, Pilimatalawe, Marathugoda, Pinewela, Pujapitiya and Bokkawela. The light

demanding crops like coffee, pepper and cloves dominated the lower canopy levels of the *gewatta*. Old trees with expanding crowns were rare, probably because they would have caused too much shade. Therefore these trees were eliminated and younger more productive species were favoured. The species diversity in these areas was extraordinary, an average garden consisted of 60 different species of trees, palms, shrubs, herbs and climbers.

The low density and low basal area documented in the area of Kandy and Marathugoda reflect the increasing building activities and the ongoing transition of life style. Ornamental plants are becoming more important and crop density is being reduced. Old trees are missing and the structural features are changing towards a more open vegetation.

- **Dominant tree species**: The „traditional" species *Artocarpus heterophyllus* (IVI 94), *Cocos nucifera* (IVI 97) and *Areca catechu* (IVI 111) still formed the most dominating structural component. The concentration on market economy and export crops however was indicated by the increasing importance of *Myristica fragans* (IVI 44), *Coffea arabica* (IVI 47), and *Syzygium aromaticum* (IVI 80). Forest species like *Caryota urens* (IVI 39) and *Neolitsea cassia* (IVI 15) were of minor importance.
- **Frequent tree species of this area** : *Michelia champaca* (61%), *Nephelium lappaceum* (45%), %), *Durio zibethinus* (42%), *Alstonia macrophylla* (39%), *Swietenia macrophylla* (37%), *Syzygium jambos* (31%), *Elaeocarpus serratus* (30%), *Melia dubia* (27%)
- **Species typical for this region and not found in the other sites are**: *Myristica fragans, Durio zibethinus, Elaeocarpus serratus, Cananga odorata, Thespesia populnea, Erythrina variegata, Corypha umbraculifera, Garcinia mangosteana, Theobroma caucau.*

Characterization

The traditional "Kandyan Forest Garden" as described in literature can be found in this area. Potential natural vegetation would be the mid-elevation wet evergreen forest. Natural vegetation covers only a very small area, including forests and patana grasslands. The economic situation of the villages is comparatively good. Different sources of income can be utilised by the farmer. People are not mainly dependent on agricultural activities for their living.

The *gewattas* found in these regions are mostly very old and still show traditional patterns of land use. Because most farmers are employed in outside activities the garden does not get much attention and management is reduced. Therefore the forest-like physiognomy is still preserved and the traditional *gewattas* are characterized by a maximum potential of diversity.

Usually traders come to the house. They collect the surplus production of fruits, nuts or spices. Their labour is partly used to harvest the betelnut (*Areca catechu*) or the coconut palm (*Cocos nucifera*). These palms are difficult to climb, educated people as well as women would not do this work. The trader sells the goods to shopkeepers in the nearby

towns. The direct income for the farmer therefore is quite low. This situation also brought some ethnic conflicts as the typical trader is usually muslim. Sinhalese traders are rarely found, due to their tradition, as it is not regarded as a respected occupation. Today this situation is seen as unsatisfactory because people realize that they sell their garden products at a cheap price and the moslem traders obtain most of the income.

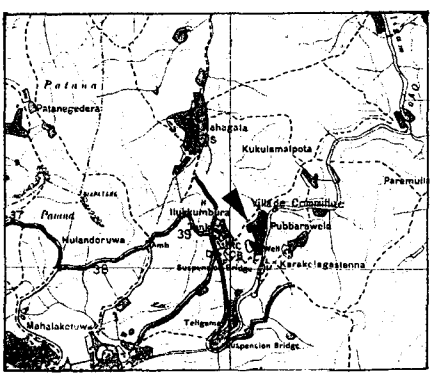
3.8.2. Group 2. Small Holder *Gewatta* of Remote Areas

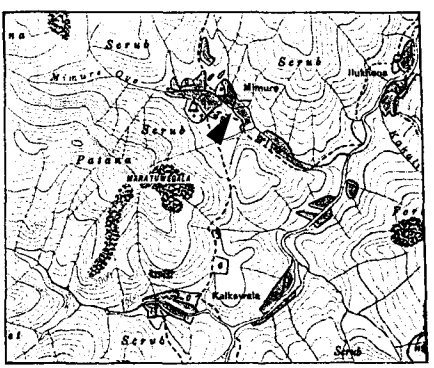
Location: Knuckles Area, (Site 4), Hapuwela (Site5)

SITE 4: Matale, Kandy District, Knuckles: Illukumbura (7°23`N, 80°46`E) Telgamuwa, Kirimatiya, Kirigankumbura, Karambagedia, Meemura (7°26`N, 80°50`E)

Matale, Kandy District, Knuckles Range: Hunnasgiriya, Illukumbura, Telgamuwa, Mahaanda, Kirigankumbura, Karabagedia, and Mimura were the villages investigated. Mimure is an example of one of the least developed villages in the district. The first road in this area was only built two years ago. Earlier the village could only be reached by a footpath (7 km). Social infrastructure facilities were limited to one primary school, a sub-post office and one cooperative retail shop. All the other villages visited had access to roads and the infrastructure facilities were comparably better. Nevertheless the Knuckles range, with a large proportion of natural forest left, is an underdeveloped region. Only in the last 30 years have human activities opened up the area, mainly for tea and cardammon cultivation. Newly buildt roads provided access to outsiders to extract forest resources (Kalansuriya, unpublished draft).

In total 23 tree gardens were visited. Most of the *gewattas* were smaller than one acre and older than 100 years. Labourers were only employed in one case. The average size of one family was 5.4 members. 7 families (out of 23) had no other off farm income. The gardens found in the area were partly established on former forest and *chena* land. Since *chena* cultivation is prohibited today, the *gewatta* needs to provide subsistence for the rural population. Climatic conditions such as winds and elevation limit the cultivation of some species like coconut (as stated by farmers).

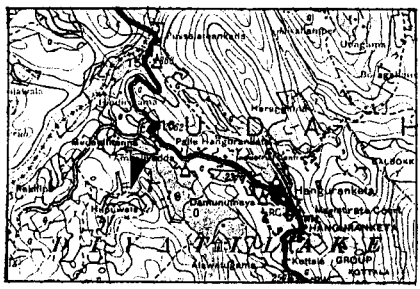




SITE 5: Nuwareliya District: Hapuwela (7°10`N, 80°46`E)

Hapuwela: The area investigated was located about 40km east of Kandy. On the marginal steep hills tobacco and vegetable cultivation took place during the main rainy season. On the midslopes we found irrigated paddy and vegetables during both seasons. Traditional villages still had well developed homegardens, new settlements on degenerated sites were part of a pilot project carried out by GTZ (Gesellschaft für Technische Zusammenarbeit) where alternative land use systems like Salt (Sloping Agricultural Land Technology) were introduced.

Our investigations were confined to the old settlements. Most of the 12 *gewattas* were not larger than 1/2 an acre. Except one younger garden all others had been inherited from previous generations. The average family consisted of 5.8 members. 10 families had no income other than from agricultural activities. Some farmers were employed in tobacco cultivation, which brought high monetary income.



Generally, high input of agrochemicals, soil erosion and huge quantities of fuel to dry tobacco leaves are necessary to maintain this form of agriculture. Usually tobacco cultivation cannot be carried on over a long period because of soil exhaustion and erosion.

General features of the smallholder *gewatta* of remote areas

- **Average size**: 3850 m^2
- **Age**: more than 100 years old
- **Family size**: 5.6
- **Management intensity**: 15 hours per week, 1% used hired labour
- **Fertilizer application**: 17% used fertilizers for vegetables and coffee.
- **Off farm income**: 48% had no other off farm icome
- **Market access**: 66% took the garden products to the nearest village shop or sometimes to the next town. Only 25% families claimed to get any income from the garden.
- **Firewood supply**: fuel supply was not sufficient for small gardens less than 2000m^2.
- **Animal component**: 42% kept cattle and livestock.
- **Structural features**: Average density was 12225 trees per hectare and average basal area was 4763 cm^2. A high number of big and old trees with large trunks contributed to the high value of basal area and the lower density value found within the areas of Hapuwela and Knuckles. These features were more comparable to forest ecosystems and were natural in their appearance. The status of these *gewattas* was more "mature" and showed the way to a climax of the plant population. The different history of the establishment of gardens in these areas might be an

explanation for the structural features. Many of these gardens were established on former forest land (as stated by the farmers) where subtle techniques like interplanting and selection of useful seedlings slowly transformed the forest system into a garden. Further more timber trees or the fishtail palm (*Caryota urens*) were left standing when the land was colonized.

- **Dominant tree species**: Subsistence production in remote areas where forest cover was left obviously favoured specific tree species. *Caryota urens* (IVI 87) and *Neolitsea cassia* (IVI 68) were more dominant in the areas of Knuckles and Hapuwela. These trees were common in the forest, they germinate by wild propagation and they could be maintained without any labour input. Harvesting and usage required traditional knowledge and skills. *Artocarpus heterophyllus* (IVI 114), *Cocos nucifera* (IVI 107) and *Areca catechu* (IVI 105) dominate the *gewatta* system according to their IVI values. *Syzygium aromaticum* (IVI 22) and *Coffee arabica* (IVI 40) did not form a major component of the system.

  Myristica fragans and *Swietenia macrophylla* were not found in these areas and *Persea americana* was only found in Hapuwela but was missing in the Knuckles area.

Characterization of the Knuckles area

The area is still covered with natural forest to a certain extent. The topographical characteristics make this region susceptible to soil erosion and landslides. Increased human activity has opened up hitherto inaccessible areas. The *gewatta* system is not as well developed as in the Kandy area. The strong influence of natural vegetation can be seen within the flora of the *gewatta* system. The economic situation of the villages is difficult and the intensified cultivation of tea and cardammon are the only means of surplus income for the farmers.

The infrastructure and economic set up of the villages does not facilitate a high income from the *gewatta* system. In 8 cases farmers did not get any monetary income from their garden. Therefore intensified cultivation of vegetables, tea or tobacco is much more desirable for farmers. A shift from the *gewatta* system towards monocultural systems is more likely to happen in this area.

- **Species typical for this region and not found commonly distributed in other sites are**: *Neolitsea cassia, Phyllanthus indicus, Semeocarpus nigro-viridis, Alstonia scholaris, Careya arborea, Achronychia pedunculata, Cipadessa baccifera, Nothobegia beddomei, Phyllanthus emblica, Grevillea robusta.*

Characterization of Hapuwela

The area shows many of the problems encountered in hazardous practices of land use like tobacco and vegetable cultivation. Natural vegetation is restricted to patana grassland and small patches of natural forest along riversides. Climatical conditions have changed during the last few years and farmers complained about the lack of water, the drying out of streams and soil erosion. Because of climatical conditions the area shows a different character in terms of its natural vegetation, with species more adapted to dry conditions. The villages investigated are old settlements with a traditional set-up.

Chena cultivation was practised until 1950 and the garden has probably received more attention since chena cultivation stopped. Farmers only planted some of the useful species like jak and coconut after 1950 (as stated by the farmers themselves). The only means of income is agriculture. More and more farmers are employed in tobacco cultivation (3 out of 12 farmers had outside income working as labourers for a tobacco company). Income from the garden is low as market facilities are not developed (Only 3 people had some monetary income from the *gewatta*).

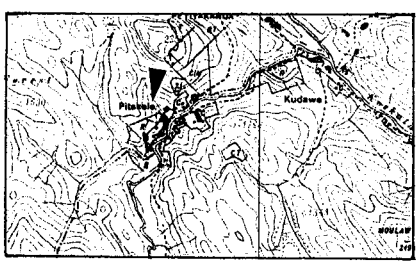
- **Species typical for this region rarely found within other areas**: *Cycas circinalis, Cestrum elegans, Flueggea sp., Filicium decipiens (*distributed by a foreign aid agency), *Phyllanthus indicus, Leucaena leucocephala, Syzygium cumini.*

3.8.3. Group 3. Intensified *Gewatta*

Location: Galle, Ratnapura District (Site 6)

SITE 6: Matara, Ratnapura, Galle District: Deniaya (6°20`N, 80°33`E), Kakundeniya, Katawella, Narandolla, Dombagoda, Lankagama (6°21`N, 80°28`E), Horragala and Pitekele (6°26`N, 80°25`E)

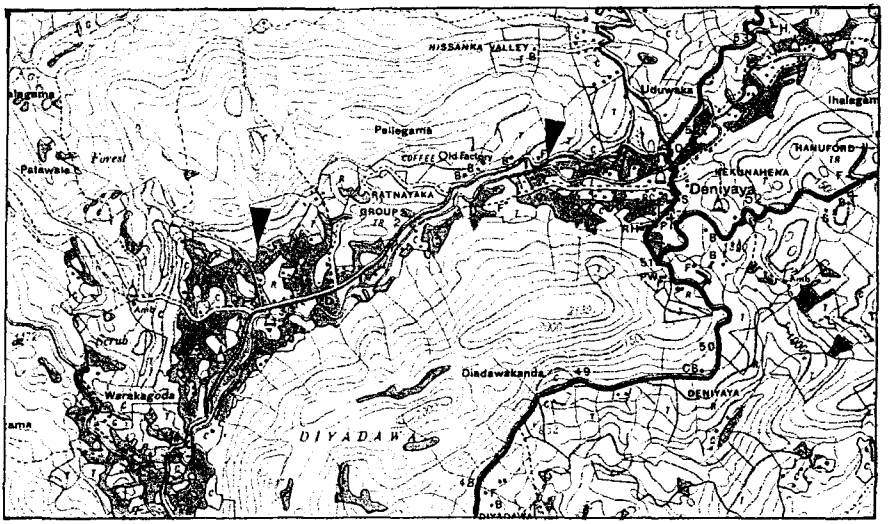
Pitekele: The village was only accessible by a footpath 1-2 hours from the road. Pitekele, means outside the forest in Sinhala. The village was stretched out along the buffer zone of the Sinharaja Man and Biosphere Reserve. Pitekele was a village of 19 households. The village economy relied on tea, rubber and jaggery (C.M. Caron, unpublished draft).



The nearest town could only be reached by a footpath. The next road with public transport was one and a half hours away. The houses were built from loam and traditional material brought from the forest, roofs were likewise thatched with plant material. The gardens were mostly smaller than one acre. Their age differed from 10 to 100 years. The average family had 5.3 members. Apart from two families all were full time farmers not engaged in other work. Tea cultivation was expanding in the area and promised monetary income.

Deniaya: 14 gardens were spread over villages close to the southern border of the Sinharaja Forest Reserve. The size of the gardens was mostly larger than one acre. Average family size was documented with 3.5 members. All of the families said that they had inherited the land from their ancestors. They had no possibility of off-farm income and were completely dependent upon agriculture. Roads and transport were difficult in this remote area. Footpaths or bad roads connected the villages. The next big town, Deniaya was three hours away. The economy depended mostly on tea production

which brought high monetary income for the farmers. The houses visited were mostly built of concrete and stones and reflected the highincome



General features of the intensified *gewatta* system

- **Size**: 5750m^2
- **Age**: 50 to 100 years old
- **Family size**: 4.4
- **Management intensity**: 35.5 hours per week, no hired labour
- **Fertilizer application**: in all cases fertilizer application, especially for tea, was practised.
- **Off farm income**: 6% obtained off farm income
- **Market access**: 21% of the farmers in Deniaya sold the garden products to a trader; all the others had to take their goods to the next village or small town which took more than two hours in some cases. Garden products are rarely sold in Pitekele.
- **Firewood supply**: This was adequate in all the surveyed gardens.
- **Animal component**: 10% had an animal component included.
- **Structural features**: The forest-like appearance of these gardens had been changed and most of the *gewattas* are restricted to a narrow belt of useful trees around the house. Species diversity, however, was maintained but density and basal area were not comparable to the above mentioned areas. Plot measurements could not be carried out and therefore no numerical data for these observations are available.

Characterization

The villages surveyed were close to the Sinharaja forest reserve. The sites are located at the North-western and Southern border of the Sinharaja Man and Biosphere Reserve. This forest, declared a World Heritage Site in 1989 is classified as Tropical Humid

Ceylonese Rainforest of the Indo Malayan realm (DE ZOYSA 1990). The village communities have always used forest resources and their every-day life is interconnected with the plant community of the forest in numerable ways. The establishment of a forest reserve where all forms of exploitation are banned has resulted in a conflict which is still ongoing today.

The intensive use of forest resources, however, has had a strong impact on the development of the *gewatta* system. A study conducted by the University of Peradeniya (McDermott, unpublished) reports that 194 species of forest plants are used in daily life. This situation has resulted in a different basis for the *gewatta* system. Chena cultivation, paddy (rice) and the forest probably formed the basic agricultural set up of these villages and the garden was of secondary importance. This situation has changed. Today chena cultivation is not practised and forest activities, like tapping the kitul palm, are only possible with a license from the forest department. Farmers have intensified the cultivation of their land by planting rubber, cinnamon and tea. The *gewatta* system found in this region is not comparable to the large and dense forest-like gardens of Kandy. The *gewatta* mainly consists of a small belt of useful tree species around the house, a closed canopy and complex vertical stratification cannot be observed.

People in these areas are mostly dependent on income from agricultural activities. (Out of the 33 gardens surveyed only two had off farm income). The economic situation and the infrastructural facilities are poor and market access is mostly difficult to obtain. Therefore garden-products were rarely sold and the *gewatta* brought no monetary income. (In Pitekele out of 19 gardens not one sold homegarden products; in Deniaya surplus products were sold to traders). In Pitekele the species composition of the gardens was mainly for home consumption and subsistance needs such as food, fuel, medicine, plant material for construction and other daily needs. In the Deniaya area it was noticeable that farmers occupied with tea cultivation mostly bought all their vegetables in town. The *gewatta* supplied only a small proportion of their living requirements. Because of the rich spontaneous vegetation the diversity of the 33 gardens investigated is still comparable to other areas, though structural and functional features have changed completely.

- **Species found in this area not common in other sites**: *Hevea brasiliensis, Cinnamomum zeylanicum, Ixora arborea, Schumacheria castaneifolia, Vateria copallifera, Pawatta indica, Dicranopteris linearis.*

3.9. Outline

The expected results, that gardens in remote areas close to natural forest were richer in species and more complex in their structure, could not to be certified. In the composition of a *gewatta* system, social structures and economic conditions strongly influenced the characteristics of the garden. Areas where farmers are mainly dependent on agriculture for their income (Site 6) generally have mostly intensified cultivation. Depending on the areas` potential and prospects they expand crops like tobacco, vegetables, tea, rubber or cinnamon have expanded. Because of the poor infrastructure market access is difficult. Many of the garden products cannot be stored or transported over a long distance. The guava, for example, has a good price in Colombo but cannot be sold in remote areas. Therefore traders and middleman still earn most of their income from garden products. This situation is not likely to change.

As long as monetary income is more desirable and necessary people will be forced to follow the trends of the market economy. This makes them highly dependent on price fluctuations and on foreign markets. Trees planted and maintained close to the house still provide some of their daily needs, though those needs might be satisfied by means of a monetary economy in the future.

In our investigations we recognized different stages of change within the *gewatta* system.

A traditional *gewatta* is characterized by high diversity of plant species, forest-like appearance, complex structural features and a natural nutrient cycle. The multiple products derived from the garden sustain some of the daily needs of rural people. Surplus monetary income provides added benefits.

Possible developments of the traditional *gewatta*:

- Gardens with ornamental plants and grass lawn may substitute the traditional *gewatta*. A reduction in the traditional uses of plants in the daily lives of people may occur. Decreasing agricultural activities may result due to the idea that, "working with your hands" is of lower value. A loss of servants or elderly people with their wealth of traditional knowledge and an urbanized, western life style may cause an increasing alienation from cultural roots.
- Tourist oriented spice gardens or tourist gardens with specialised products like spice powder, herbal tea, handicrafts may develop. This should result in an increasing income from the garden.

Possible developments of the smallholder *gewatta*:

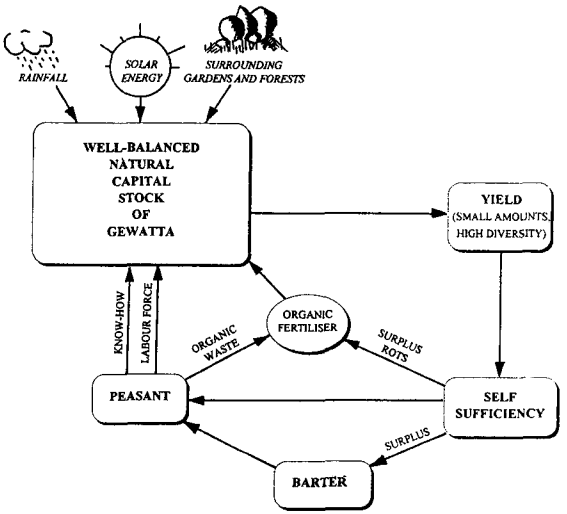
- The difficult economic situation in these areas does not allow the farmer to earn any income from the *gewatta*. As long as no other possibilities are to be seen farmers will not change the system as it still sustains their fuel and food consumption. If cash crops can be grown and are propagated in the area, a shift to the intensified *gewatta* is most likely to happen.

Possible developments of the intensified *gewatta*:

- Structural features have already changed, the forest-like plant community is reduced to a belt-like ring of trees which is concentrated around the compound of the house. All other suitable land is converted into cashcrop production. Species diversity is still maintained although the structure and function of the system are destroyed. Long term sustainability of soil and production are questionable.

The following figure shows the economic cycle of the traditional *gewatta* system before the introduction of money on a widespread basis.

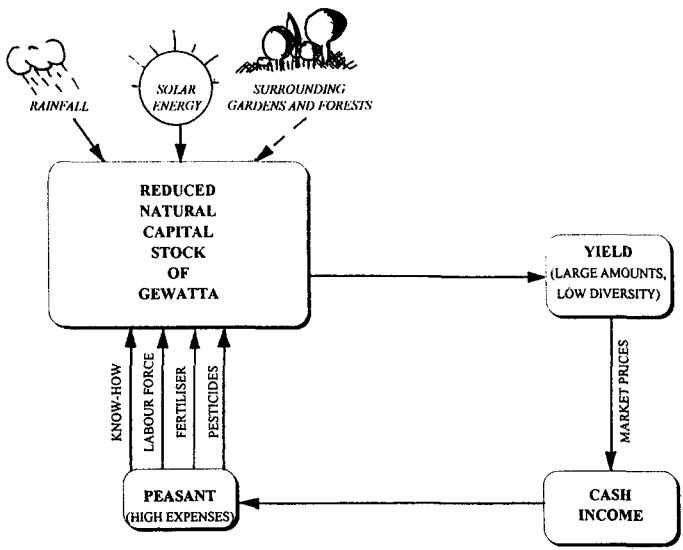
Figure 3.30. Economic cycle of a traditional *gewatta* (A. Zinggl)



With the introduction of money the traditional system has to face various changes. On the one hand new opportunities to use the garden more efficiently and to enjoy enhanced benefits arise. The surplus can be sold at a local market and the earnings can either be saved or invested in the education of children or simply used for a higher standard of living. On the other hand the farmer has to face higher costs, such as those for the transportation of goods to the market, or the rising fixed costs of a higher standard of living. Particularly the changing socio-economic background, characterized by advanced division of labour, offers additional jobs to the labour market. A diversification of consumer goods can also be observed as well as an increasing demand for these. The latter are available for money only. All in all the farmer is not only tempted but even forced to earn cash money. Therefore he has to plant cash-crops in the long run with the the negative side-effect of disturbing the garden's ecological stability, high diversity and natural nutrient cycle.

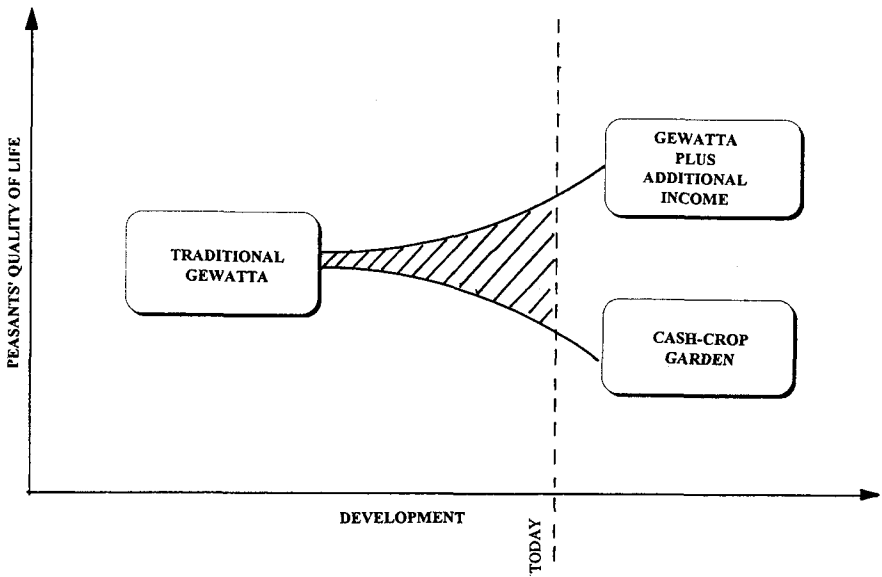
Hence, the farmer has to decide between two different strategies. One is the option of living on the mere agricultural income of the garden, but with some sort of specialisation towards cash-crop production (such as spices, tobacco, etc.) and an increased input of labour. In the long run this also means that fertilisers and pesticides have to be applied in the garden, causing higher costs and environmental degradation. Additional costs arise with the loss of the useful by-products which characterize the original concept of homegardens, such as fuel-wood, medicinal plants, herbs, thatching materials, and various others. These increasing costs again force the farmer to earn cash-money.

Figure 3.31. Economic cycle under pressure of the market-economy (A.Zinggl)



The other option is that of looking for additional income from non-agricultural work, or from paid work in plantations or paddy-fields. The chances to do so depend on the availability of labour-force capacities among the family members, on their education, on the availability of jobs on the labour-market, and several other factors, which means that the decision between these two paths of strategies is not open to every farmer equally. From the ecological point of view the latter option is the more hopeful one, because the traditional concept of extensive agroforestry can be continued, and the increasing demand for consumer goods can be covered by economic activities not directly changing the structure of the garden, with its abundant variety of species and its ecological stability.

Figure 3.32. Economic cycle of a *gewatta* with additional income (A. Zinggl)



3.9.1. Are the Farmers Satisfied with the *Gewatta* System?

The questionnaire carried out amongst the farm families included a short discussion about their attitudes towards the *gewatta* system. A total of 105 farmers were interviewed, out of this number 47 families expressed some discontent with and criticism of the *gewatta* system. Some of the arguments often heard can be stated as follows:

Some farmers mentioned that an important component of the garden was missing. They wanted to include some additional species like timber trees, banana, rambutan, tea, coconut, cinnamon, pepper, coffee or vegetables in the *gewatta*. Other criticisms mentioned were that they would like to plant new varieties which would bring a better income; or they were not satisfied because they did not see any chance of getting better monetary income from the garden; the unorganised nature of the garden and the problem of too many old trees were mentioned in another case.

The remaining 58 families were relatively satisfied with their garden and did not want to change anything. Being guided through the garden by so many women and men, we

often had the impression that they had a strong attachment to their environment. Though they rarely stay in the garden for enjoyment as we do, their lives are still closely linked to the *gewatta*. Usually the garden is not fenced but borders are marked and known by everyone. Free access for people coming to the house is common. The garden is therefore also a place for social events and get togethers. The *gewatta* contributes a lot to the dignity and well-being of rural people.

Summarising our observations we can say that half of the questioned farmers were not really satisfied with the *gewatta* system. But most of them had no concrete idea on how to change the situation. The way of thinking observed with the rural dwellers is not easily understandable for a foreign observer. First of all it is not usual for people to believe in an active transformation of their ideas. To need more coconut trees is one thing but to actually go out and plant them is another thing. People do not tend to actually plant the trees according to their needs. Active planning, designing and changing is not characteristic of the villager. Rather we find passive adaptation to the circumstances. Some general characterizations of the villagers` attitudes can be stated as follows:

- Concern about their children`s future is voiced yet future planning does not take place. The concept of tomorrow and planning in a certain time sphere is not a common one.
- Changes will only take place on a village level. Individual decisions are quite rare. The traditional values and the conservative character of Sinhalese society is still very strong and the individual`s decisions will stay rooted in the mainstream.
- Competitive thinking is uncommon. The fact that muslim traders earn most of the income from garden products is recognized but not competed against.

Today`s situation with its economic pressures and growing needs, certainly brings about many conflicts within the society which ultimately results in disintegrated development. The *gewatta* manifests a time when small needs were easily sustained from small means.

3.10. A Forest-Like Habitat for Animals

> *The village has many things - it is not only significant because of its human population. It is significant because of its water, because of its animals and because of its trees.* Banwari[3]

In Sri Lanka it is not really necessary to visit a forest site for birdwatching. It is easy to find a considerable number of bird species in traditional villages. This can be explained by the high diversity of trees found in the homestead gardens of a traditional village. These gardens create a valuable environment for the birds as well as for the farm family. The combination of trees and birds enlivens a village. The villagers' day starts early with the birds' calls and songs as they wake up to the tune of nature's rhythms.

Up until now not much attention has been given to bird studies in village sites. We will present some preliminary results based on personal observations during the frequent visits to different *gewatta* systems.

Depending on the structure and diversity of the *gewatta* different species of birds can find a habitat there. The distribution of birds in forests and homegardens is comparable. A forest-like *gewatta* has different layers of trees and shrubs showing the same structure as a natural forest. Therefore it is not surprising to find birds such as the *Brown Wood Owl* in a homegarden. This bird needs a dark and undisturbed place to stay there during the day, as it is only active during the night, when it moves slowly and completely noiselessly through the garden. The farmer can be sure that this inhabitant will control the population of mice and rats.

For a bird the main attraction of a garden is the large variety of different fruits, flowers or insects found there. Different species of birds prefer different foods and different layers of a garden. Some examples can illustrate this:

The *Common Barbler* is abundantly found in homegardens. It is rarely seen alone, and usually a small crowd of *Barblers* can be seen near the garbage plot and on the lower branches of trees and shrubs where they search for insects and worms. A keen observer would notice that one bird usually stays higher up in a tree in order to give warning to the others in case of danger. This fact is known to some other bird species who often accompany the *Barbler* flocks. If a rich undergrowth is missing in a garden these birds are not so commonly found there.

The *Orange Breasted Blue Fly Catcher* is found in the middle layer of a garden or forest. It prefers shady, dense and undisturbed parts where it can hide well. An attentive observer can see it skillfully catching flying insects. Its bright colours sparkle for a short moment between the shadows of the trees and then it is hidden behind some branches. It usually sticks to a certain area and there it controls insects and pests, thus being a great benefit to the farmer.

[3] Banwari ist the editior of *Jansata* a "Hindu" daily newspaper, published in Delhi

In contrast the *Ceylon Lorikeet* can always be seen flying high above the crowns of the trees. It does not search for insects but instead it feeds on flowers. From above it selects a tree where it feeds and rests for a short time before it goes up into the sky again. Coconut and the kitul flower are its preferred food. It even comes to drink from the toddy pot (A vessel to collect the sap of the kitul flower which is used to prepar an alcoholic drink, toddy) and some unlucky birds have been known to fall into that pot. The bird contributes to the fertility of a garden because it does not only feed on the flowers, but also pollinates them.

A homegarden gives not only food to the birds but also shelter. For example the *Indian Pitta* migrates to Sri Lanka from India, staying in forests and homegardens. It needs a thick and dense vegetation cover with more than one tree layer in order to feel at home and settle there.

Another bird depending on dense and forest like vegetation is the *Bronze-wing Pidgeon*. This bird likes to move and fly among the trees where it is always protected. It does not like to fly over open space or grass lands for example. The homegarden thus offers an ideal environment for it's activities.

In comparison to the forest-like *gewatta*, tea plantations and clove dominated gardens with low diversity were observed. The tree layers and the structural features of these plantations are poor compared to the forest and traditional *gewatta*. The main bird activity is confined to the upper layer of the plantation, amongst mostly shade-giving trees such as *Grevillea robusta* where the birds roost for some moments. The undergrowth of a monoculture plantation is similarly poor in species and structure. Birds are very sensible to environmental factors, especially when selecting a place suitable for them to nest. The number of species therefore found in monocultural plantations is rapidly sinking. The use of agrochemicals and the absence of food and shelter for the birds are further factors.

One of the common bird species found in the more intensively cultivated plantations was the *White Back Munia*. This bird lives in grasslands, selecting trees for nesting and breeding. Forest birds, however, were missing in monocultural gardens which clearly shows that the biodiversity of flora and fauna correlates with the birdlife found there.

The following table shows the distribution of bird species during 30 minutes of observation morning and evening. A complete list of birds commonly found in homegardens is given in the appendix.

Table 3.11. Distribution of bird and plant species in selected homegardens.

Nr. Area	*type of garden average size 3000m²*	*average number of birds**	*average number of plants*
1 Pilimatalawe	forest-like	10.5	80
2 Kiribathkumbura	forest-like	16.5	120
3 Pilimatalawe	partly disturbed	9.5	126
4 Kandy	spice garden	12	105
5 Pilimatalawe	forest-like	12	97
6 Udawattekelä	semi natural forest	14.5	>100
7 Pitekele	forest-like, close to a stream	18.5	53
8 Pitekele	forest-like	10	53
9 Pitekele	forest-like	12.5	48
10 Pitekele	forest-like	10	48
11 Singharaja	natural rain forest	13.5	>200
12 Welianga	clove and pepper dominated garden	6	57
13 Pilimatalawe	tea plantation	3.5	< 10
14 Singharaja	tea plantation	1	< 10
15 Pitekele	tea plantation	1	< 10

* Observations of birds during 30 minutes morning and evening

This table shows a big difference between the different forms of cultivation. The traditional *gewatta* with its forest-like structure and high diversity of tree species is an ideal habitat for a high number of birds. The main reason is the great variety of different foods, plants and insects as well as the different layers and structural components of a garden. Therefore the *gewatta* system has an important task in preserving a rich and diverse wildlife. The results of a bird-survey, carried out in the Velimada-Bandaranda area, add further weight to the above mentioned survey, indicating that the forest gardens accommodated an even greater diversity of birds than remnant natural forests (NUBERG et al. 1994).

The variety of birds is also dependent on the adjacent vegetation. There is a big difference between a homegarden situated close to a paddy field, close to a natural forest or close to a river. This explains the exceptions in the above figures of number 3 and 7. Garden number 7 is located close to a river whereas number 3 borders on a main road.

Another factor influencing the distribution of bird species is the different fruiting season of the trees. Depending on the season some birds might be more abundant than others.

For long distance flying birds the *gewatta* functions as an important resting and feeding place. If the land-use were dominated by plantation agriculture these birds would certainly vanish. The natural vegetation of the wet and intermediate zone was

originally dominated by different types of forest. Today the forest cover is restricted to small areas, so not only many plants but also many animals have lost their natural habitat. The *gewatta*, however, with its forest-like appearance, functions as a substitute. This fact is also true for other animals like small mammals and insects. *The Black Palm Civet* (an indian palm-cat) is a good example of one of these animals. The kitul tree commonly found in homegardens is dispersed by the droppings of the civet. There are no other means of propagation and the tree is very useful for the rural population. This and other symbiotic interaction between plants and animals ultimately benefits the farmer, and long term productivity is guaranteed.

Mostly all surveyed *gewattas* were not seriously affected by pests and diseases. Birds contribute to a large extent to the control of insects. Thus the amount of agrochemicals used in comparison to other forms of agriculture is negligible in the *gewatta* system. The healthy production of food with low cost input is thereby sustained. The balanced coexistance of human beings, plants and animals that we can observe within a homegarden can thus offer a model for sustainable agriculture.

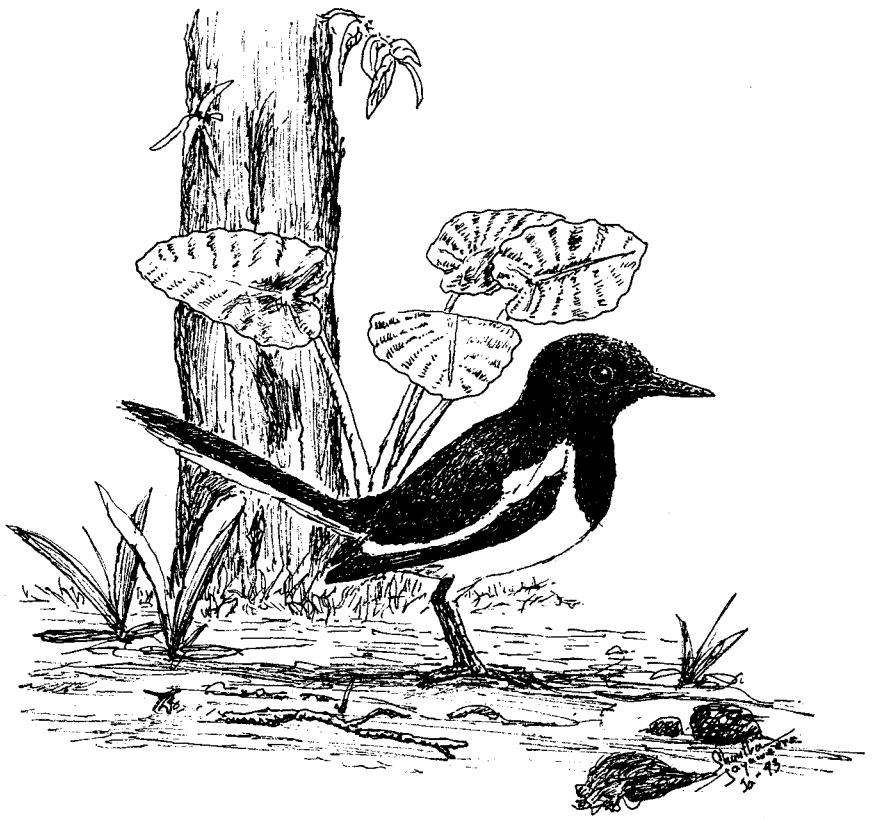


Figure 3.33. Southern Magpie Robin

3.11 Farming Like the Forest - The Nutrient Cycle of the *Gewatta* System

3.11.1. Introduction

We should study the forest in order to farm like the forest.
Sir Albert Howard

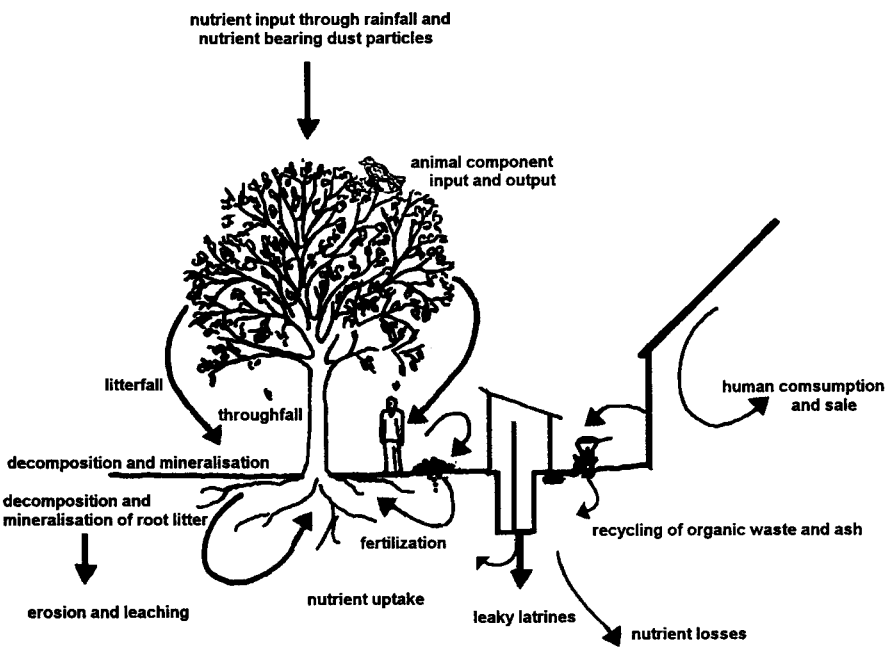
The *gewatta* agro-ecosystem investigated here is characterized by a permanent process of transfer, storage and dissipation of energy within the system. The community of plants, animals and human beings forms a functional system persisting in a balanced equilibrium which has evolved over a long period of time.

The main pathways of nutrient cycles through tropical forest ecosystems have been recognized as canopy throughfall, root detritus and litterfall. Also soil invertebrates and the process of decomposition contribute to the cycle (Whithmore, 1990).

Likewise the *gewatta* system follows the principle of the nutrient cycle typical for the tropical rainforest.

The next figure shows a simplified model of the cycles found in the *gewatta* system

Figure 3.34. A simplified model of the nutrient cycle of the *gewatta* system



An essential question underlaying our research was the question of sustainability. The obvious continuation of production over centuries without any organized method of fertilization is striking; therefore the gardens are said to be self-fertilising by recycling fallen leaves, flowers and fruits. „These features are so obvious that no-one has measured them. A nutrient-cycle study of a home garden would be of interest in showing the magnitudes of nutrient flows and the degree of recycling" (Young, 1990). These questions focused our interest and an experiment was designed dealing with soil conditions and litterfall in the *gewatta* system as well as in a comparable, adjacent forest ecosystem. In the following section we will present some basic results of this detailed investigation of the nutrient cycle[1].

We selected different types of gardens located in the village Pilimatalawe and Kiribathkumbura near Peradeniya and Kandy for our investigations.

3.11.2. Location and Characterization of the Chosen Sites

- **Kiribathkumbura (KI)**, 640m, (7°16`N, 80°34`E): The garden measures 14 ha (35 acres) and is 200-300 years old. It is characterized by extensive cultivation, a forest-like structure, large undisturbed parts, and is dominated by traditional tree species (jak, coconut, arecanut, timber trees). The owners have no other income except from their paddy fields.
  Vegetation: forest-like, rich and diverse: *Cocos nucifera, Caryota urens, Michelia champaca, Gliricidia sepium, Albizzia odoratissima, Artocarpus heterophyllus* are the most dominant tree species ranked after the basal area.
  Number of species: 170
  Stratification: tree height maximum 30m, 3-4 strata,
  thick litterlayer, dense crown cover, on the hilltop open crown cover,
  Undergrowth: tree seedlings are randomly distributed, mostly close to the mother trees, patches are densely covered by herbs along the slope, on the hilltop *Panicum maximum* dominates.
  Slope: 10-30%
  Management: extensive management, fertilizer is only used for a small area where pepper is cultivated.

- **Pilimatalawa, Arambegama 1 (AR1)**, 650m, (7°16`N, 80°32`E): The garden measures 2025m² (1/2 acres) and is 20 years old. It is characterized by intensive management, typical smallholder ownership and traditional tree species (coconut, jak) mixed with cash crops (pepper, cloves). The garden only supplies the farmers with a subsidiary income
  Vegetation: dominated by *Cocos nucifera, Artocarpus heterophyllus, Areca catechu* and *Cedrella toona*, named after ist dominance in the basal area. Closed crown cover occurs only patchwise, the vegetation is rather disturbed because of building activities, the garden has been divided and a second house has been built.

[1] For the complete data of the nutrient cycle see Hochegger, K. (1995): The Kandyan Forest Gardens, *Gewatta*, of Sri Lanka. Their Ecology, Economy and Culture. Ph.D. Thesis, Agricultural University of Austria, Vienna.

Number of species: 126
Stratification: tree height maximum 30m, 3 strata, slope 1-3%, poor litterlayer.
Undergrowth: dominated by grasses, *Setaria sp.* and planted vegetables, like yams and banana
Slope: mostly flat, 2-3%
Management: fertilizer and agrochemicals are not applied, preparation of compost, building of erosion gullies, planting of vegetables, and watering are the main agricultural activities.

- **Pilimatalawa, Arambegama 2 (AR2)**, 650m, (7°16`N, 80°32`E): The garden measures 7100m² (1 1/2 acres) and is over 150 years old. It is characterized by extensive cultivation, typical smallholder ownership and a traditional set up of plants. The garden and a paddy field supply the income for the entire family.
Vegetation: forest-like, dense and diverse, dominated *by Michelia champaca, Cocos nucifera, Areca catechu* and *Caryota urens.*
Number of species: 97
Stratification: tree height maximum 30m, 3-5 strata, slope 3-5%, thick litter layer.
Undergrowth: rather poor, dominated by the family *Zingiberaceae* and different seedlings.
Slope: 5-10%
Management: Because the farmer is mainly involved in paddy cultivation the garden is extensively managed, fertilizer is not used, nor are agrochemicals applied, most of the species are not planted but grow by wild germination.

- **Pilimatalawe Welianga (WE)**, 640m, (7°16`N, 80°32`E): The garden measures 1.62 ha (4 acres) and is 38 years old. It was converted into a garden from a tea- and later coffee -plantation. It is characterized by intensive cultivation, dominated by cash crops (pepper,cloves) and influenced by fertilizer application. The garden has the character of a plantation rather than of a traditional *gewatta.* Structural components are less complex and species diversity is reduced for the sake of the intensification. The owners have other sources of income.
Vegetation: dominated by *Syzygium aromaticum*, cultivation of *Piper nigrum* on *Gliricidia sepium* and *Grevillea robusta.*
Number of species: 57
Stratification: tree height maximum 30m, 2 strata,
Undergrowth: dominated by grasses, *Panicum maximum, Mikania cordata,*
Slope: 5-10%
Management: intensive management, fertilizer is used for pepper, agrochemicals are not applied, pest control is not necessary.
- **Udawattekelä (UK)**, 540-645m, (7°18`N, 80°38`E): This semi-natural forest located north of Kandy town was used as reference to compare our data on litterfall and other ecological features. Udawattekelä was declared a protected forest reserve in 1938 and today it is a Man and Biosphere Reserve. Because of destruction due to logging of forest patches 21ha of 84ha were replanted between 1922-1936.

Therefore the forest can be divided into areas with natural vegetation and planted areas.

Forest-type: Tropical Lowland Rainforest *Artocarpus, Pometia, Filicium* zone (GRELLER, BALASUBRAMANIAM, 1980).

The number of species was documented as 460 plant species including 135 tree species (KARUNARATNA, 1986). Out of these 9 are endemic. Different blocks of the reforested area were planted with different combinations in terms of species. Natural regeneration occurs in these areas and today the forest can be called a semi-natural, secondary forest. In fact it can be used as a good example for successful forest plantation. Further more the forest is an important catchment area for many streams.

Stratification: tree height maximum 30m, 3-4 strata, varied microrelief.

Undergrowth: the dense undergrowth is dominated by *Calamus*, and different tree seedlings, *Caryota urens, Artocarpus nobilis*, dense litterlayer.

Slope: depending on microrelief up to 30%.

- **Tea plantation (TEE),** 660m close to Arambegama 2 (7°16'N, 80°32'E) The vegetation was domitated by tea bushes, poor undergrowth, some shade trees (*Grevillea robusta*), and a poor litter layer.

The above mentioned gardens and the forest site were visited regularly every other week which enabled us to develop a profound relationship with the farmers. The experiments carried out at these four sites were litterfall sampling, studies on soil, and detailed investigations on vegetation and management practices including zoological surveys and phenological studies.

3.11.3 General Results Describing the Ecological Features of the Nutrient Cycle

- **The traditional, forest-like *gewatta* sustains soil fertility**

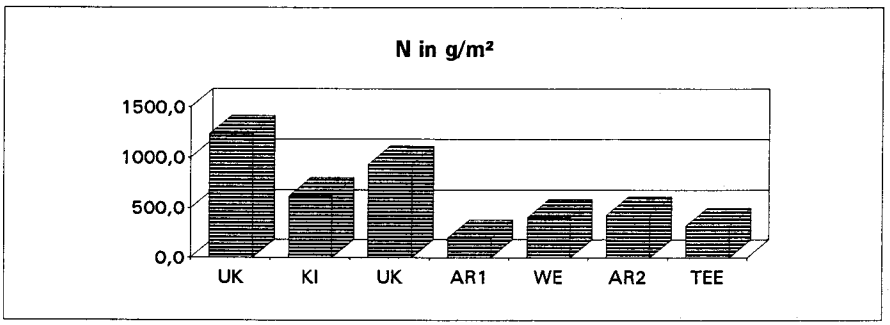
Soil fertility is defined as the capacity of soil to support the growth of plants, on a sustained basis, under given conditions and other relevant properties of the land (YOUNG 1991). Soil fertility forms the basis of sustainable agriculture. The decline of soil fertility during the conversion from natural vegetation to managed agro-ecosystems is one of the major proplems of tropical landuse systems.

The soils of our study sites developed mainly from parent material deriving from mixed, intermediate or basic metamorphic rocks from the pre-cambrian (gneiss, granite) series which are highly crystalline. Depending on morphological properties of diagnostic horizons and exchange capacity the developed soilprofiles can be classified as Cambisols, Acrisols or Luvisols, the local soil forms ranking from Brown Earth, Yellowish Brown Earth, Reddish Brown Earth to Red Loam. Mostly because of their high content of coarse material (> 2mm) the soils are well to medium well drained. The influence of site morphology on the depth of the rooting horizon (accumulation or depletion of fine mineral soil material) is quite obvious and influences water capacity and water conductivity to a high extent. In general these physical features are quite balanced. Soil structure is well developed and reflects an

intensive perturbation by soil meso-fauna and high rooting activity. Despite the presence of charcoal in some profiles, soils of the *gewatta* systems show poor human impact on morphological soil features: marks of cultivating processes as input of organic fertilizers or seed bed preparation are not observable.

Our study soil profiles of the *gewatta* system showed a similar nutrient content to the forest site (table 3.12.). The maximum amount of nitrogen in t/ha was obviously found in Udawattekelä (UK), ranging from 12.36 to 13.85t/ha for 50cm mineral soil. The minimum amounts with, 1.36 to 4.61 t/ha for 50cm of mineral soil, were found in the intensively cultivated smallholder *gewatta*, established on a former tea plantation in Arambegama (AR1). A similar distribution could be observed with carbon, which can be seen in the following figure (3.35.). A complete list of the different amounts of nutrients is shown in table 3.36.

Figure 3.35. Distribution of N and C for the different sites investigated



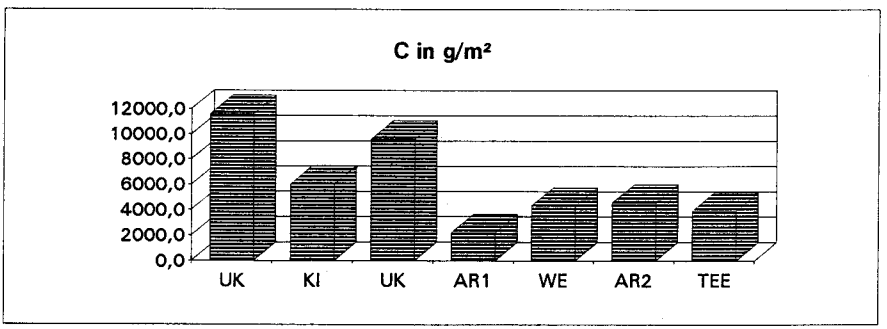


Table 3.12. Nutrient content of different soil profiles, in g/m² of 50 cm mineral soil (MS), humus layer (Ao) and total (sum).

Abbreviations used as follows: LO.... Location, Pr.... Soil Profil

LO	Pr		N	C	P	K	Ca	Mg	Na	Mn	Fe	Al
UK	1	MS	1365	12379	771	69	1093	378	36	48	8.0	19
		Ao	15	497	4	3	27	4	3	50	0.3	134
		Sum	1380	12876	775	72	1120	382	39	98	8.3	153
UK	2	MS	950	9164	531	48	787	243	25	33	5.3	13
		Ao	8	275	2	1	15	2	3	25	0.1	49
		Sum	958	9439	533	49	802	245	28	58	5.4	62
UK	3	MS	1385	13222	672	58	1225	351	25	55	6.6	12
		Ao	12	298	3	1	016	3	5	46	0.2	138
		Sum	1397	13520	675	59	1241	354	30	101	6.8	150
KI	4	MS	811	8689	436	39	979	276	37	23	7.6	9
		Ao	3	96	1	1	4	1	1	9	0.1	26
		Sum	814	8785	437	40	983	277	38	32	7.7	39
KI	5	MS	645	6178	321	20	1054	293	27	34	5.0	18
		Ao	5	135	1	1	8	1	1	9	0.1	23
		Sum	650	6313	322	21	1062	294	28	43	5.1	41
KI	6	MS	626	5162	242	26	763	205	21	43	4.1	14
		Ao	6	228	3	2	10	3	3	31	0.3	90
		Sum	632	5390	245	28	773	208	24	74	4.4	104
KI	7	MS	398	4101	200	27	320	81	17	43	3.1	20
		Ao	7	155	2	1	8	2	3	23	0.1	49
		Sum	405	4256	202	28	328	83	20	66	3.2	69
UK	8	MS	602	633	371	48	277	98	25	70	5.4	27
		Ao	10	331	3	3	19	3	5	61	0.2	170
		Sum	612	6564	374	51	296	101	30	131	5.6	197
UK	9	MS	1236	12264	547	55	1265	296	55	37	9.4	16
		Ao	8	322	2	2	16	2	3	25	0.3	55
		Sum	1244	12586	549	57	1281	298	58	62	9.6	71
UK	10	MS	965	10368	447	54	859	293	29	42	4.9	12
		Ao	10	338	3	3	14	3	3	53	0.2	131
		Sum	975	10706	450	57	873	296	32	95	5.1	143
AR1	11	MS	461	4984	356	19	189	51	22	29	3.8	23
		Ao	4	118	1	1	7	1	1	12	0.1	27
		Sum	465	5102	357	20	196	52	23	41	3.9	50
AR1	12	MS	135	1401	232	18	213	48	12	6	2.0	1
		Ao	1	41	0	0	3	0	1	4	0.1	14
		Sum	136	1442	232	18	216	48	13	10	2.1	15
AR1	13	MS	267	3063	120	27	207	42	15	13	2.9	2
		Ao	4	150	2	11	3	2	2	95	0.1	201
		Sum	271	3213	122	28	210	44	17	108	3.0	203
AR1	14	MS	198	2197	180	28	200	34	8	10	1.3	1
		Ao	4	88	1	0	3	1	1	70	0.1	75
		Sum	202	2285	181	28	203	35	9	80	1.4	76
WE	15	MS	406	4323	407	25	54	10	21	25	3.6	76
		Ao	4	161	1	1	5	1	7	80	0.1	111
		Sum	410	4484	408	26	59	11	28	105	3.7	187
AR2	16	MS	383	4253	293	16	231	59	12	19	2.0	1
		Ao	7	180	2	2	11	2	3	136	0.2	160
		Sum	390	4433	295	18	242	61	15	155	2.2	161
AR2	17	MS	506	5157	271	14	293	69	11	23	2.0	1
		Ao	12	268	3	1	15	3	4	141	0.1	145
		Sum	518	5425	274	15	308	72	15	164	2.1	146
AR2	18	MS	322	3919	292	8	43	9	9	30	1.9	30
		Ao	4	94	1	0	4	1	6	62	0.1	76
		Sum	326	4013	293	8	47	10	15	92	2.0	106

The proportion of carbon and nitrogen can be used as an indicator of site quality. Nitrogen has a significant effect on plant growth and is determined by mineralisation during decomposition of organic matter. The tree based *gewatta* is characterized by an increase of soil organic matter through litterfall and decomposition and by nitrogen fixation of various leguminous trees. In our investigations the C/N ratio usually shows a steady decrease from upper to deeper soil layers with a considerable difference between mineral soil and the humus layer. This distribution reflects the decreasing amount of carbon with proceeding decomposition. The natural forest and *gewatta* systems do not reveal a considerable difference in C/N ratio.

The results of table 3.12. show an obvious grouping of gardens in two extremes. One is the natural forest with the highest amounts of nutrients; the other is found in the tea plantation, the spice plantation and the smallholder *gewatta*, which were all low in their nutrient content (except for aluminium and sulphur). The low content of nitrogen and carbon gives evidence of the intensive cultivation. The most balanced nutrient content was found in Kiribathkumbura (KI), the large, forest-like garden and in the traditional garden in Arambegama (AR2). There the *gewatta* system obviously maintains a sustainable level of nutrients.

The distribution of soil pH indicates a similar grouping, increasing acidity was documented with plantation agriculture, whereas the forest and the forest-like *gewatta* showed considerably higher values.

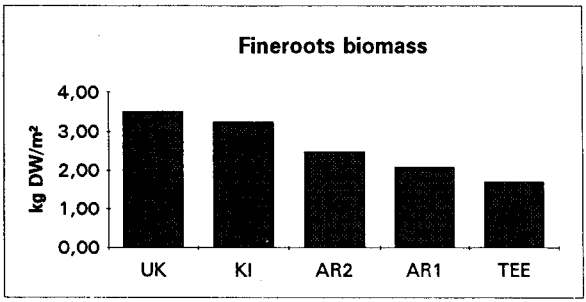
Table 3.13. Mean value of pH (H2O) and pH (Cacl2) of the sites

Site	pH (H_2O)	pH ($CaCl_2$)
UK	5.8	5.4
KI	6.2	5.0
AR2	5.7	5.3
AR1	5.6	4.9
Welianga	4.6	4.3
Tea plantation	4.7	4.3

- **The *gewatta* system has a complex and dense stratification of roots**

The dense vegetation of different perennials as well as herbaceous plants suggests the idea of a complex stratification of the root system. For the nutrient cycle of the *gewatta* system, however, root distribution is of great importance. Nutrient availability, transfer and weathering are improved by the the root system. In our study we observed the distribution of fine roots biomass in different soil profiles, the highest amounts of fine roots biomass were found below 10cm. Different rooting horizons will bind nutrients which would otherwise be lost from the system.

Figure 3.36. Distribution of fineroot biomass



The distribution of root biomass reflects the distribution of available nutrients within an ecosystem (JORDAN 1985). The results of fine roots biomass and nutrient content of the different sites show therefore a similar distribution. The highest values are documented for the forest and the forest-like traditional *gewatta* system, lower values are observed in the more intensive cultivated sites.

- **The dense and forest-like vegetation of the traditional *gewatta* system has a comparatively high input of litter**

Fine litterfall, defined as leaves, fruits, flowers and woody debris is identified to be one of the main pathways of the nutrient cycle. 5 to 8 tons of leaf litter per hectare and year is the average turn-over rate of a traditional *gewatta* system. This figure comes close to what is known from the natural forest systems of South Asia. The constant input of leaf litter improves the organic layer of the soil. Earthworms or other invertebrates and the innumerable amount of microbes feed on the leaves and support rapid decomposition rates and nutrient release.

Figure 3.37. Soil fauna has an important role in the nutrient cycle

Not only the quantity but also the diversity of leaf litter is an important factor for soil fertility. Each species has a different chemical composition and therefore enriches the soil with different elements. Thereby a variety of microbes are stimulated in their activity.

The results (seen in table 3.14., 3.15.) show the obvious analogy of the forest and *gewatta* system.

Table 3.14. Mean value of fine litter input in g dry mass (DM) / m^2 / year

Location	Traps°	Leaves	Trash	Twigs	Flowers	Fruits	Total
UK1	4	446	84	120	25	35	712
UK2	4	504	116	103	26	116	867
KI	5	354	50	25	16	15	457
AR1	4	360	59	106	5	74	606
AR2	2	581	105	149	20	18	873
WE	4	372	60	68	8	9	518

°Number of traps established in the area

Table 3.15. Total fine litterfall in t / ha

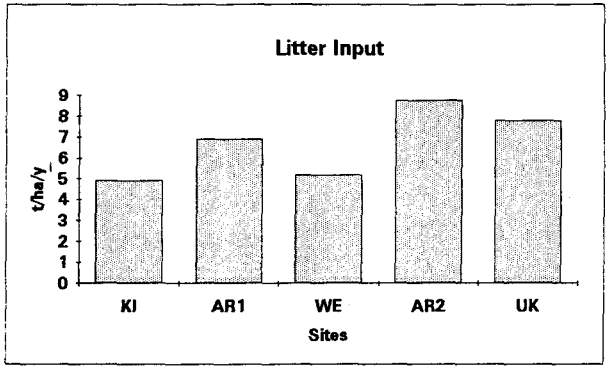
Location	Total fine litterfall
UK2	8.26 t/ha
UK1	7.10 t/ha
AR2	8.73 t/ha
AR1	6.89 t/ha
KI	4.90 t/ha
WE	5.19 t/ha

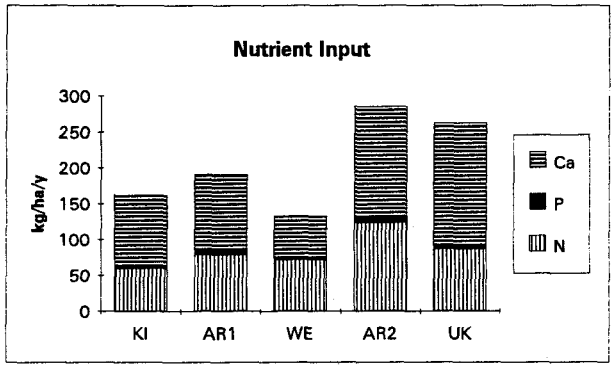
The striking similarity between the forest and traditional *gewatta* system underlines the hypothesis that the nutrient cycle of the *gewatta* system works on the same principles as the forest-ecosystem. Structural components and species richness are an essential basis of this system and are strongly correlated to litterfall. A tendency towards monocultural cultivation modifies structural components and thereby leads to a decrease in litterfall and litter diversity. Likewise the input of nutrients is lower and the process of self-fertilization is not sufficient enough to guarantee long term productivity. Welianga (WE) was evidently poor in the diversity of species found in litter traps (the mean value was 5 species), whereas all other sites (except the tea plantation where litter input is insignificant) had a comparably high diversity ranging from 14 to 17 species.

Welianga was dominated by clove trees and pepper cultivation. A high concentration of clove (*Syzygium aromaticum*) leaves with their content of oil might influence litter decomposition. Some farmers stated that too many clove trees would make the soil infertile, and therefore a coconut tree, for example, would not bear fruits. A similar observation was presented in a study of village forest gardens in Java (BOMBARD et al. 1980) and further investigation of this question would be interesting.

The following figures (3.38.) show quantity and nutrient content of litter input.

Figure 3.38. Litter input in terms of quantity and nutrient content





Litterfall in terms of quantity and quality in the *gewatta* and the forest-ecosystem are comparable. In all sites phosphorus content is evidently low and seems to be the limiting factor in the nutrient cycle.

- **A high percentage of leguminous plants is found in the *gewatta* system**

These plants with their nitrogen fixing root nodules improve the nitrogen cycle. Traditional methods of fertilisation seem to reflect this. In Indonesia for example, a common saying expresses this knowledge: "The earth likes butterfly flowers." "Butterfly flowers" is an expression for leguminous plants with their typically shaped flowers. The *Leguminosae* have been identified to be the most important plant family of the *gewattta*, with a total of 42 different leguminous species found in all structural layers of a garden. It can be assumed that they contribute to the nutrient cycle of the *gewatta* system by increasing the nitrogen level of the soil.

- **The forest-like character of the vegetation reduces soil erosion**

Annual soil loss of mixed homestead gardens has been recorded as ranging just below natural forest (Wickramasinghe, 1988).

Table 3.16. Effect of land use on soil erosion *

land use	annual soil loss in m^3 km^2 y	slope (degrees)
tea	755	30-35
tobacco	1302	25-32
mixed homestead	57	28-30
natural forest	45	30-35

* Source: WICKRAMASINGHE, 1988

It can be assumed that the closed crown cover and the multi-storey structure of the *gewatta* system reduces soil erosion, thus preventing surface runoff. Among man-made systems the *gewatta* is the most advantageous in preventing soil erosion. Farmers' knowledge in different methods of biological erosion control are a promising base for further research. In our survey 17 plant species were mentioned by farmers which were used for soil conservation. Dense undergrowth, increase of soil organic matter and a complex stratification of the root system also contributes to soil conservation. The *gewatta* system follows the principles of forest ecosystems where nutrients are accumulated against the process of erosion and leaching.

- **Due to the complex organisation of the gewatta system with a high number of species and lifeforms pests and diseases are minimised**

Vertical stratification and optimal use of sunlight are characteristic features of the traditional *gewatta* system. The first and most obvious effect of diversity is the huge variety and number of leaves spread out in the sunlight. Furthermore different kinds of flowers and fruits create various food chains. The nutrient cycle works more efficiently when the diversity of species is maintained. Different chemical composition of leaves ensure a diverse medium for various microbes and soil fauna. Further more a rich and diverse fauna of insects, birds and small mammals can be sustained.

In our investigations we found that diversity is independent of farm size. The average size of the investigated gewattas was 5250m^2, ranging from 0.1 to 14 ha. The number of species did not vary accordingly. Similar findings were documented by McConnell (1992): "A large three- to five-acre farm is as likely to be as diverse and carry as many species as a small one-acre farm". The number of species, however, varied between 22 to 170 species of trees, shrubs and herbs for one garden. The average number of species was 53 for a garden not counting the ornamental species around the house. This results in a higher diversity of plants in small farms. The negligible problems with weed control, pests and diseases can be attributed to the diversity of the gewatta system. The establishment of different webs and cycles is determined by species diversity. The chemical diversity characteristic of the different plant species of the gewatta confronts insects and pathogens, making epidemics, so common to agricultural monocultures,

rare. These interconnections produce a functioning agro-ecosystem where dominance of a small number of plants or insects does not occur.

- **Only a small proportion of the entire biomass is harvested**

In fact many garden products are not harvested but rot in the garden. Further more most of the products harvested are consumed by the family and are thereby recycled and retained within the system. Left over food, ashes and kitchen waste also contribute to the nutrient cycle. In our survey only a small number of farmers (about 10%) prepared compost but generally only some trees or vegetables close to the kitchen were treated with organic waste. These practices contribute to the entire nutrient supply of the agro-ecosystem. Generally, human impact on the *gewatta* is still very low and the natural processes are not disturbed. The main human activity consists of harvesting the different homegarden products.

- **The entire productivity of the *gewatta* system is high**

Output of an agro-ecosystem is described by monetary income and products which provide subsistence needs. Apart from direct cash income the productivity of the *gewatta* system seems very high and it is necessary to rethink the economic parameters which determine market structures and income facilities.

In our survey we did not ask for information on prices and monetary income, as the reliability of this data would be questionable (farmers did not like to speak about their income). The data obtained from another study (McCONELL 1992, 35) show that the average gross income per farm and year does not exceed 14030 Rupees ranging from 4740 RS` to 48580 RS`.

The income we estimated varied according to the areas and market facilities. Knuckles, Hapuwela, Pitekele and Deniaya had low income from garden products and specialised on crops like tea, tobacco, jaggery or rubber. The income in the other areas is probably comparable to the above mentioned data. A general feature of the *gewatta* system is the small amount of garden products which are kept for sale. The 142 farmers interviewed mentioned different crops which are sold (table 3.17.).

Other products mentioned to be sold occasionally were avocado, vanilla, rubber, cinnamon, breadfruit, jakfruit, timber and vegetables. The surplus production of different fruit trees, ornamental plants like anthurium or firewood were also sold. The number of gardens where farmers sell their products is probably not representative of the true picture as farmers were sometimes not willing to give detailed information about their income. Therefore the results can only describe a certain trend. Depending on the infrastructure of the village, access to a nearby market is sometimes difficult. Extreme examples are the Knuckles area and Pitekele as well as Deniaya, where access to the nearest market was difficult. In these areas the income from garden products is low and a shift towards cash crop production can be observed.

Table 3.17. Products mainly used for sale in the different areas investigated. The given numbers indicate the amount of gardens which sell a certain product.

Location	Kandy	Pilima-talawe	Pine-wela	Bokka-wela	Puja-pitiya	Knuck-les	Deni-aya	Pite-kele
gardens	11	35	16	9	15	26	14	16
outside income	9	22	10	9	13	12	2	0
cloves	6	10	10	8	14	2	3	-
tea	-	-	-	4	-	-	8	13
pepper	5	7	4	5	7	5	8	-
nutmeg	4	3	6	1	6	-	-	-
banana	4	3	5	3	2	4	7	-
coffee	3	6	7	3	7	3	3	-
coconut	3	3	6	-	3	4	1	-
betel nut	2	4	4	-	4	3	6	-
kitul penny	1	2	-	-	-	-	2	9
total of products sold	8	8	7	6	7	6	8	2

The main stock of plants described in the previous chapters forms the average base for subsistence production. This basic produce of a traditional *gewatta* is meant to sustain most of the daily needs. The diversity of plant species guarantees maximum use of space and light with minimum input of energy, labour and capital. This system provides a minimum risk for the farmer. Crop failure, price fluctuations, pests and diseases, the main threats of intensive agricultural systems, do not endanger the *gewatta* system. This leads to long term stability and sustainability.

The results of detailed documentation from three farmers in the area of Kandy yielded an average of 399kg FW(fresh weight) of vegetables and spices, of 1007 pieces of different fruits including coconut and 1407 kg FW of firewood per year and garden (average size of 7000m^2). Converting the pieces of fruits into kg FW the overall estimation for the productivity of an average garden of half an hectare lies between 1000 to 2000kg FW of different products, including firewood per year. These figures can be used as an example to show that the economic profitability of the *gewatta* system must be considered from a different viewpoint.

Including all by-products, medicine, fodder, plants used for body care and plants used for religious purposes, the productivity of an average garden is very high. Converting

the subsistence needs sustained by the *gewatta* into monetary values, the entire income would be an impressive figure.

3.11.4. Conclusion

This short summary of some of the aspects of the nutrient cycle of a *gewatta* system shows the highly complex relations and links between the different elements of a garden. The basic principle of long term sustainability, however, is the forest like character of the ecosystem. Diversity of species and the structural features are the important premises for a functioning nutrient cycle.

As in the forest ecosystem the *gewatta* optimises natural resources like sunlight and nutrients, and long-term soil fertility is maintained. As a result of such evidence it seems necessary to contradict the widely spread view that the traditional *gewatta* system is an unorganised and unproductive form of agriculture. On the contrary, it is a very well adapted system of land-use.

Usually the promise of conventional development is, that by following in the footsteps of the "developed" countries of the world, the "underdeveloped" countries can become rich and comfortable too. "Following the footsteps" also means changing and modifying traditional methods of agriculture according to western models. Thereby the *gewatta* system would be transformed into a systematic production mode.

This book should strenghten the argument for the opposite development. The qualities inherent in the age-old *gewatta* system should above all be understood and appreciated: the immense diversity of plant species, the simple and low cost mode of production, the efficient process of self-fertilization, the rich habitat enlivened by numerous animals and the resulting resistance against pests and disease. Farming like the forest is a new challenge for tropical land-use systems, having proved itself over the centuries to offer a viable alternative to western models.

3.12. The *Gewatta* - A Remnant of the Past or a Hopeful Model for the Future ?

> *... we ask whether the present society fulfills basic human needs like love and security and access to nature. We ask which society, which education is beneficial for all life on the planet as a whole, and then we ask further what we need to do in order to make the necessary changes.*
> Arne Naess (Norwegian Philosopher)

The *gewatta* system is a unique form of land use, well adapted to the ecological conditions of Sri Lanka. The forest-like gardens cover 14.5 percent of the island's total area, 24.2 percent of the wet and and 13.1 percent of the intermediate zone, where the lion's share of the population lives.

Once more, it has to be pointed out that the abundant diversity of (plant) species is the basic precondition for its sustainability. The forest-like structure guarantees the optimal use of space and sunlight. Thereby a well functioning nutrient-cycle can be established and long-term soil fertility can be maintained. The *gewatta* with its forest-like appearance, offers a habitat for a number of birds, insects and small mammals and functions as a substitute for the declining area of natural forests.

At the same time the *gewatta* provides many of the daily needs of a growing population. An average homegarden of 0.5 ha can supply the total amount of fire-wood, and further more vegetables, fruits and spices for a whole family. Medicinal plants and the use of wild growing species (green leaves) contribute to a healthy diet.

The *gewatta* system is characterized by low inputs: fossil fuel is not required, running costs are minimal and human labour is comparatively low, basically recorded for harvesting and to a smaller extent for maintenance. However, monetary income is still very low due to the characteristics of a subsistence agriculture. This is also the reason for its low contribution to the present Gross National Product (GNP). If the environmental capital would be considered in its calculation the situation would be completely different. The *gewattas* have, so to say, a high value, but no price.

The typical characteristics (properties) of the *gewattas* are the minimisation of risks (such as pests, diseases or crop failure) and the high adaptability to changing circumstances. Quite a number of new (cash-crop) products have been introduced during the last centuries such as clove, nutmeg, coffee, tea or papaya. The forest-like features, however, have not yet been replaced in their characteristics, so that nowadays a high number of crops can be found in the homegarden which do not have their origin in Sri Lanka.

Even the greatest challenge for the *gewatta* system so far, the development of the monetary market, has been faced more or less by adding some cash-crop products (such as pepper, cloves, vanilla or cardammom) to the other species without

reduction of the diversity. And due to the relatively low labour input, earnings in non-agricultural jobs can complete the income of a household. Finally, the modern market itself offers niches for the products of homegardens. Due to the rising health consciousness (primarily in urban areas) a demand for agricultural products without application of pesticides can be recorded. The lacking marketing strategies could easily be established.

The *gewatta* system is capable of facing different economic or climatic changes without disadvantages. As long as the basic ecological features defined as diversity, a forest-like structure and an efficient nutrient cycle remain unchanged, the mode of production can be changed in many ways.

The *gewattas* still offer immense possibilities and in order to preserve their potential more attention should be paid to their manifold benefits. In order to increase the public awareness a set of measures, such as the following, can be sugggested:

- **Education and training:** Starting with school children and including all levels of the community of a village, this can create awareness about homegarden cultivation. Optimising the processing and storage of garden products can be improved thereby. The creation of a course of lectures with particular emphasis on the *gewatta* system can produce some specialists on the subject.

- **Encouragement of local culture:** In our opinion local culture is a very strong instrument for further development. Traditional media like dance and drama can be used to convert and spread new messages of ecology and conservation. The Buddhist culture offers many options for conservation strategies and for the establishment of a sustainable man-nature relationship.

- **Establishment of a research institute:** At present *gewattas* are probably somewhere at the "bottom" of the priority list and are subjected to only isolated research. There are no institutions today which have both the mandate and the competence to deal with the diverse problems associated with homegardens. Therefore, an institution could be set up with a clear "national policy and management plan" aimed at maximizing the efficiency of the *gewatta* system. This could be something parallel to the Tea Research Institute, the Coconut Research Institute, the Rubber Research Institute, or the Forest Department etc.

The tasks of such an "Institute for Applied Homegarden Research" could also include the training and education of farmers. The results could be implemented within a short period and thereby contribute to the overall welfare very soon. The institute could establish international links in order to share the knowledge possessed by the different countries that have similar homegarden systems. The improvement of public awareness on homegardens through international and national workshops could be another target.

Rising awareness and increasing research would improve knowledge and understanding of the traditional *gewatta* system. This would yield new models of landuse based on traditional farming systems. The *gewatta* system could be used for the reforestation of degraded lands. They fulfill the task of biological erosion control and at the same time provide some income for the farmer.

Finally, it has to be said that there is a lot to be learned from traditional farming systems. The *gewatta* system still follows the patterns and processes discernible in natural ecosystems. Therefore it can be used as a model for sustainable agriculture where natural processes still remain the most appropriate method available.

This book is a contribution to a better comprehension of the *gewatta* system. It should encourage further research and implementation of traditional agricultural systems. Farming like the forest represents a challenge to the development of sustainable agriculture in the tropics.

APPENDIX

DIFFERENT USES OF HOMEGARDEN PLANTS

Abbreviations used: T... timber, F...fuel, Fr...fruits, V...vegetables, B...beverages, S...spices, M...medicine, St...stimulant, O...oils, Fi...fibre, Or...ornamental, Ta...tatching, G...gums, Or...ornamental, Fo...fodder, W...weed,
So...soil conservation, R...support plant, Wr...wrapping, P...pioneer, Ty...toy, R...religious, C...cultural, Fe...fencing, D...dye, U...unknown, C...cashcrop, L...compost

FAMILY	SPECIES	T	F	Fr	V	B	S	M	St	O	Ta	Fi	To	G	Or	Fo	W	So	R	Wr	P	Ty	R	C	Fe	D	U	C	L
ACANTHACEAE	Barleria prionitis							X									X												
ACANTHACEAE	Hygrophila spinosa																										X		
ACANTHACEAE	Thunbergia sp..														X														
AGAVACEAE	Agave vera-cruz											X						X											
AMARANTHACEAE	Achyranthes aspera							X									X												
AMARANTHACEAE	Aerva lanata					X		X									X												
AMARANTHACEAE	Alternanthera sessilis				X			X									X												
AMARANTHACEAE	Amaranthus oleraceus				X																								
AMARANTHACEAE	Amaranthus paniculatus				X																								
AMARANTHACEAE	Amaranthus tricolor				X																								
AMARANTHACEAE	Cyathula prostrata																										X		
AMARYLLIDACEAE	Crinum latifolium																										X		
ANACARDIACEAE	Anacardium occidentale	X		X				X		X				X															
ANACARDIACEAE	Lannea coromandelica							X																					
ANACARDIACEAE	Mangifera indica	X	X	X												X							X						
ANACARDIACEAE	Mangifera zeylanica	X	X	X																			X						

FAMILY	SPECIES	T	F	Fr	V	B	S	M	St	O	Ta	Fi	To	G	Or	Fo	W	So	R	Wr	P	Ty	R	C	Fe	D	U	C	L
ANACARDIACEAE	Nothopegia beddomei	X	X																										
ANACARDIACEAE	Semecarpus nigroviridis	X	X					X																					
ANACARDIACEAE	Spondias altitis																										X		
ANACARDIACEAE	Spondias pinnata			X																									
ANACARDIACEAE	Spondias pinnata			X																									
ANNONACEAE	Annona muricata			X																									
ANNONACEAE	Annona reticulata			X			X																						
ANNONACEAE	Cananga odorata	X	X																		X								
ANNONACEAE	Goniothalamus gardneri																										X		
ANNONACEAE	Polyalthia longifolia														X														
ANONACEAE	Cyathocalyx zeylanicus						X																						
APIACEAE	Trachyspermum roxburghianum							X									X												
APOCYNACEAE	Allamanda cathartica														X														
APOCYNACEAE	Alstonia macrophylla	X	X															X			X								
APOCYNACEAE	Alstonia scholaris	X	X					X					X									X							
APOCYNACEAE	Catharanthus roseus							X							X														
APOCYNACEAE	Ervatamia divaricata														X								X						
APOCYNACEAE	Ichnocarpus frutescens																										X		

FAMILY	SPECIES	T	F	Fr	V	B	S	M	St	O	Ta	Fi	To	G	Or	Fo	W	So	R	Wr	P	Ty	R	C	Fe	D	U	C	L
APOCYNACEAE	Plumeria acuminata														X								X						
APOCYNACEAE	Plumeria alba														X								X						
APOCYNACEAE	Rejoua dichotoma							X																					
APOCYNACEAE	Wrightia antidysenterica							X																					
ARACEAE	Xanthosoma sagittifolium				X																								
ARACEAE	Acorus calamus						X	X		X																X			
ARACEAE	Alocasia cucullata				X															X				X					
ARACEAE	Alocasia macorrhiza																			X				X					
ARACEAE	Amorphophallus paeoniifolius				X			X																					
ARACEAE	Anthurium sp.														X									X			X		
ARACEAE	Arisaema leschenaultii							X																					
ARACEAE	Colocasia esculenta				X										X					X				X					
ARACEAE	Lasia spinosa				X			X																					
ARACEAE	Syngonium angustatum																												
ARALIACEAE	Polyscias balfouriana				X										X														
ARALIACEAE	Schefflera stellata														X														
ARISTOLOCHIACEAE	Aristolochia indica							X			X						X												
ASCLEPIADACEAE	Calotropis gigantea							X							X		X												
ASCLEPIADACEAE	Dregea volubilis				X			X																					
ASCLEPIADACEAE	Hemidesmus indicus					X		X									X												

FAMILY	SPECIES	T	F	Fr	V	B	S	M	St	O	Ta	Fi	To	G	Or	Fo	W	So	R	Wr	P	Ty	R	C	Fe	D	U	C	L
ASCLEPIADACEAE	Sarcostemma brunonianum							X																					
BALSAMINACEAE	Impatiens sp..														X														
BAMBUSACEAE	Bambusa vulgaris	X	X										X		X			X	X			X		X	X				
BAMBUSACEAE	Ochlandra stridula														X														
BASELLACEAE	Basella alba				X																								
BEGONIACEAE	Begonia malabarica														X														
BIGNONIACEAE	Oroxylum indicum		X					X														X							
BIGNONIACEAE	Stereospermum personatum	X	X																						X				
BIGNONIACEAE	Stereospermum suaveolens	X	X					X																					
BOMBACACEAE	Bombax ceiba	X	X										X																
BOMBACEAE	Ceiba pentandra	X											X																
BOMBACEAE	Durio zibethinus	X	X	X																									
BROMELIACEAE	Ananas comosus			X				X																					
BURSERACEAE	Canarium zeylanicum	X		X				X		X																			
CAMPANULACEAE	Lobelia nicotianifolia																X												
CANNACEAE	Canna indica				X										X					X				X					
CANNACEAE	Canna indica														X					X				X					
CARICACEAE	Carica papaya			X										X								X							
CELASTRACEAE	Gymnosporia emarginata																										X		
COMBRETACEAE	Terminalia belerica	X						X																					
COMBRETACEAE	Terminalia catappa	X	X		X																X								

FAMILY	SPECIES	T	F	Fr	V	B	S	M	St	O	Ta	Fi	To	G	Or	Fo	W	So	R	Wr	P	Ty	R	C	Fe	D	U	C	L
COMBRETACEAE	Terminalia parviflora																										X		
COMMELINACEAE	Commelina benghalensis																X												
COMMELINACEAE	Commelina diffusa																X												
COMPOSITAE	Ageratum conyzoides							X								X	X												
COMPOSITAE	Bidens pilosa																X												
COMPOSITAE	Conyza floribunda																X												
COMPOSITAE	Eleutheranthera ruderalis															X	X												
COMPOSITAE	Emilia sonchifolia																X												
COMPOSITAE	Eupatorium odoratum																X												
COMPOSITAE	*Gynura sp..*																X												
COMPOSITAE	Microglossa zeylanica																X												
COMPOSITAE	Mikania cordata							X								X	X												
COMPOSITAE	Synedrella nodiflora				X										X														
COMPOSITAE	Tithonia diversifolia															X	X												
COMPOSITAE	*Tridax procumbens*																X												
COMPOSITAE	Vernonia cinerea																X												
COMPOSITAE	Wedelia trilobata																X												
COMPOSITE	Tagetes erecta														X								X						
CONVOLVULACEAE	Argyreia populifolia							X									X												
CONVOLVULACEAE	Ipomoea aquatica				X																								

FAMILY	SPECIES	T	F	Fr	V	B	S	M	St	O	Ta	Fi	To	G	Or	Fo	W	So	R	Wr	P	Ty	R	C	Fe	D	U	C	L
CONVOLVULACEAE	Ipomoea batatas				X																								
CONVOLVULACEAE	Ipomoea mauritiana							X																					
CONVOLVULACEAE	Ipomoea obscura							X																					
CONVOLVULACEAE	Merremia sp..																										X		
CRASSULACEAE	Kalanchoe pinnata							X																					
CRASSULACEAE	Kalanchoe pinnata							X							X														
CRUCIFERAE	Brassica oleracea						X	X																					
CRUCIFERAE	Brassica juncea							X																					
CUCURBITACEAE	Benincasa hispida				X			X																					
CUCURBITACEAE	Cucumis melo			X																									
CUCURBITACEAE	Cucumis sativus				X																								
CUCURBITACEAE	Cucurbita maxima				X																								
CUCURBITACEAE	Cucurbita moschata				X																								
CUCURBITACEAE	Luffa acutangula				X																								
CUCURBITACEAE	Momordica charantia				X			X																					
CUCURBITACEAE	Sechium edule				X																								
CUCURBITACEAE	Trichosanthes anguina																										X		
CUCURBITACEAE	Trichosanthes cucumerina				X																								
CYCADACEAE	Cycas circinalis			X				X																					
CYPERACEAE	Cyperus exaltatus																X												
CYPERACEAE	Cyperus rotundus							X									X												
DILLENIACEAE	Dillenia retusa							X																					
DILLENIACEAE	Schumacheria castaneifolia																				X								

FAMILY	SPECIES	T	F	Fr	V	B	S	M	St	O	Ta	Fi	To	G	Or	Fo	W	So	R	Wr	P	Ty	R	C	Fe	D	U	C	L
DILLENIACEAE	Wormia triquetra																										X		
DIOSCOREACEAE	Dioscorea alata				X																								
DIOSCOREACEAE	Dioscorea penthaphylla				X																								
DIOSCOREACEAE	Dioscorea spicata				X																						X		
DIOSCOREACEAE	Dioscorea trimenii																										X		
DIPTEROCARPACEAE	Vateria copallifera	X			X										X														
EBENACEAE	Diospyros ebenum	X											X																
EBENACEAE	Diospyros insignis	X	X																										
EBENACEAE	Diospyros koenigii	X	X																										
EBENACEAE	Diospyros malabarica	X	X																										
EBENACEAE	Diospyros sylvatica	X																											
ELAEOCARPACEAE	Elaeocarpus serratus			X																									
ERYTHROXYLACEAE	Erythroxylum moonii							X																					
EUPHORBIACEAE	Acalypha hispida														X														
EUPHORBIACEAE	Acalypha indica							X									X												
EUPHORBIACEAE	Agrostisstachys hookeri										X																		
EUPHORBIACEAE	Aleurites moluccana									X											X								
EUPHORBIACEAE	Bridelia retusa		X					X																					
EUPHORBIACEAE	Cleistanthus pallidus																										X		
EUPHORBIACEAE	Codiaeum variegatum														X														
EUPHORBIACEAE	Croton laccifer							X																					X

FAMILY	SPECIES	T	F	Fr	V	B	S	M	St	O	Ta	Fi	To	G	Or	Fo	W	So	R	Wr	P	Ty	R	C	Fe	D	U	C	L
EUPHORBIACEAE	Croton tiglium																												
EUPHORBIACEAE	Drypetes sepiaria	X	X		X																								
EUPHORBIACEAE	Euphorbia antiquorum							X							X														
EUPHORBIACEAE	Euphorbia heterophylla							X							X														
EUPHORBIACEAE	Euphorbia hirta							X							X														
EUPHORBIACEAE	Flueggea sp..																X												
EUPHORBIACEAE	Glochidion stellatum																										X		
EUPHORBIACEAE	Hevea brasiliensis	X	X											X								X							
EUPHORBIACEAE	Jatropha curcas							X																					
EUPHORBIACEAE	Jatropha podagrica							X																					
EUPHORBIACEAE	Macaranga peltata		X		X			X													X								
EUPHORBIACEAE	Mallotus fuscescens																										X		
EUPHORBIACEAE	Mallotus phillippensis		X					X																					
EUPHORBIACEAE	Mallotus rhamnifolius		X																										
EUPHORBIACEAE	Manihot esculenta				X													X				X							
EUPHORBIACEAE	Manihot glaziovii																	X							X				
EUPHORBIACEAE	Pedilanthus tithymaloides																										X		
EUPHORBIACEAE	Phyllanthus debilis			X				X																					
EUPHORBIACEAE	Phyllanthus emblica																												
EUPHORBIACEAE	Phyllanthus indicus	X	X																										

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EUPHORBIACEAE	Putranjiva zeylanica							X																					
EUPHORBIACEAE	Ricinus communis							X		X																			
EUPHORBIACEAE	Sapium indicum							X																					
EUPHORBIACEAE	Sauropus androgynus				X																				X				
FLACOURTIACAEAE	Hydnocarpus venenata							X																					
FLACOURTIACEAE	Flacourtia inermis			X																									
FLACOURTIACEAE	Flacourtia ramontchi			X				X																					
FLACOURTIACEAE	Homalium zeylanicum																										X		
FLACOURTIACEAE	Scolopia schreberi																										X		
GENERIACEAE	Klugia notoniana																										X		
GRAMINAE	Eleusine coracana				X			X																					
GRAMINAE	Eleusine indica							X								X	X												
GRAMINAE	Eragrostis tenella																X												
GRAMINAEAE	Cymbopogon citratus						X										X												
GRAMINAEAE	Cymbopogon sp..																X												
GRAMINEAE	Axonophus affinis															X	X												
GRAMINEAE	Chrysopogon sp.																X												
GRAMINEAE	Coix lacrima-jobi														X							X							
GRAMINEAE	Cyrtococcum sp..																X												
GRAMINEAE	Digitaria sp..															X	X												
GRAMINEAE	Imperata cylindrica										X						X												
GRAMINEAE	Oplismenus compositus																X												

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GRAMINEAE	Panicum maXimum															X	X												
GRAMINEAE	Pennisetum sp..																X												
GRAMINEAE	Saccharum officinarum				X		X																						
GRAMINEAE	Setaria barbata															X	X												
GRAMINEAE	Setaria verticellata															X	X												
GRAMINEAE	Vetiveria zizanioides																X	X											
GRAMINEAE	Zea mays				X																								
GUTIFFERAE	Garcinia xanthochymus																												
GUTIFFERAE	Garcinia cambogia			X			X	X						X															
GUTIFFERAE	Garcinia mangostana			X																									
GUTIFFERAE	Garcinia morella		X					X																					
GUTIFFERAE	Garcinia tinctoria		X																										
GUTTIFERAE	Mesua ferrea	X						X							X								X	X					
GUTTIFERAE	Mesua nagasarium	X													X														
HIPPOCARATEACEAE	Salacia reticulata							X																					
ICACINACEAE	Nothapodytes foetida																										X		
LABIATAE	Anisomeles indica							X									X												
LABIATAE	Coleus amboinicus														X														
LABIATAE	Hyptis capitata																X												
LABIATAE	Leucas biflora																X												
LABIATAE	Leucas zeylanica							X																					
LABIATAE	Mentha sp.							X																					
LABIATAE	Ocimum sanctum							X															X						

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LABIATAE	Plectranthus zeylanicus							X									X												
LABIATAE	Pogostemon heyneanus																												
LAURACEAE	Cinnamomum zeylanicum						X	X																					
LAURACEAE	Cryptocarya sp..							X																					
LAURACEAE	Litsea glutinosa		X					X																					
LAURACEAE	Litsea glutinosa							X																					
LAURACEAE	Neolitsea cassia	X	X				X																						
LAURACEAE	Persea americana	X	X	X												X													
LECYTHIDACEAE	Caereya arborea		X		X			X																					
LEEACEAE	Leea indica							X																					
LEGUMINOSAE	Abrus precatorius							X														X		X					
LEGUMINOSAE	Acacia caesia																X												
LEGUMINOSAE	Acacia nilotica							X																					
LEGUMINOSAE	Adenanthera pavonina							X														X							
LEGUMINOSAE	Albizia lebbeck	X	X															X			X								
LEGUMINOSAE	Albizia odoratissima	X	X															X			X								
LEGUMINOSAE	Bauhinia tomentosa														X														
LEGUMINOSAE	Caesalpinia bonduc							X																					
LEGUMINOSAE	Cassia auriculata					X		X																					
LEGUMINOSAE	Cassia fistula							X							X						X								
LEGUMINOSAE	Cassia tora							X																					
LEGUMINOSAE	Clitoria ternatea							X									X												

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LEGUMINOSAE	Crotolaria laburnifoila																										X		
LEGUMINOSAE	Cynometra cauliflora																										X		
LEGUMINOSAE	Cynometra ramiflora																										X		
LEGUMINOSAE	Dalbergia sp..														X														
LEGUMINOSAE	Desmodium gyrans							X																					
LEGUMINOSAE	Desmodium heterophyllum							X								X	X												
LEGUMINOSAE	Desmodium pryonii															X	X												
LEGUMINOSAE	Desmodium triflorum							X								X	X												
LEGUMINOSAE	Dolichos lablab				X																								
LEGUMINOSAE	Erythrina lithosperma		X													X		X							X				X
LEGUMINOSAE	Erythrina variegata		X					X								X		X							X				
LEGUMINOSAE	Gliricidia sepium		X													X		X	X		X								X
LEGUMINOSAE	Indigofera tinctoria							X																					
LEGUMINOSAE	Leucaena leucocephala		X													X		X							X				X
LEGUMINOSAE	Mimosa pudica							X																					
LEGUMINOSAE	Myroxylum balsumum							X																		X			
LEGUMINOSAE	Pericopsis mooniana	X																											
LEGUMINOSAE	Phaseolous vulgaris				X																								
LEGUMINOSAE	Phaseolus lunatus				X																								

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LEGUMINOSAE	Pongamia pinnata							X					X					X							X				
LEGUMINOSAE	Psophocarpus tetragonolobus				X																								
LEGUMINOSAE	Pterocarpus indicus	X	X																		X								
LEGUMINOSAE	Pterocarpus marsupium	X	X					X																					
LEGUMINOSAE	Pterocarpus santalinus							X																					
LEGUMINOSAE	Pterospermum canescens	X	X																										
LEGUMINOSAE	Samanea saman	X	X												X						X								
LEGUMINOSAE	Saraca indica							X							X														
LEGUMINOSAE	Vigna cylindrica				X																								
LEGUMINOSE	Sesbania grandiflora				X			X																					
LEGUMONISAE	Tamarindus indica	X	X	X			X	X																					
LILIACAE	Aloe vera							X							X														
LILIACEAE	Asparagus falcatus							X							X														
LILIACEAE	Asparagus racemosus							X							X														
LILIACEAE	Gloriosa superba							X							X														
LOGANIACEAE	Strychnos benthamii																X												
LOGANIACEAE	Strychnos nux-vomica							X																					
MAGNOLIACEAE	Magnolia fuscata																										X		
MAGNOLIACEAE	Michelia champaca	X	X																										
MALPIGIHIACEAE	Hiptage benghalensis																X												

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MALVACEAE	Abutilon hirtum							X									X												
MALVACEAE	Hibiscus esculentus				X	X																							
MALVACEAE	Hibiscus furcatus							X																					
MALVACEAE	Hibiscus primulinus																										X		
MALVACEAE	Hibiscus rosa-sinensis														X														
MALVACEAE	Sida acuta							X									X												
MALVACEAE	Sida acuta							X									X												
MALVACEAE	Sida veronicaefolia							X									X												
MALVACEAE	Thespesia populnea	X	X					X										X							X				
MALVACEAE	Urena lobata							X									X												
MARANTACEAE	Maranta arundinacea				X																								
MARANTACEAE	Stachyphrynium zeylanicum				X																								
MELIACEAE	Azadirachta indica	X						X															X	X					
MELIACEAE	Cedrellus toona	X	X																					X					
MELIACEAE	Cipadessa baccifera																X					X							
MELIACEAE	Melia dubia	X	X																										
MELIACEAE	Swietenia mahagoni	X	X																										
MELOSTOMACEAE	Osbeckia aspera																X												
MELOSTOMACEAE	Osbeckia octandra							X									X												
MENISPEMACEAE	Coscinium fenestratum							X					X																
MENISPERMACEAE	Anamirta cocculus				X			X			X																		
MENISPERMACEAE	Cissampelos pareira							X									X												

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MENISPERMACEAE	Cyclea burmanni							X					X				X												
MENISPERMACEAE	Stephania japonica							X									X												
MENISPERMACEAE	Tinospora cordifolia							X																					
MENISPERMACEAE	Tinospora malabarica							X																					
MORACEAE	Artocarpus altitis	X	X		X															X									
MORACEAE	Artocarpus heterophyllus	X	X	X	X			X								X						X		X	X	X			
MORACEAE	Artocarpus incisus	X	X		X																								
MORACEAE	Artocarpus lackoocha	X	X	X																									
MORACEAE	Artocarpus nobilis	X	X		X																								
MORACEAE	Ficus arnottiana																										X		
MORACEAE	Ficus benghalensis							X					X										X						
MORACEAE	Ficus hispida							X																					
MORACEAE	Ficus racemosa							X																					
MORACEAE	Ficus religiosa																						X						
MORACEAE	Morus alba																										X		
MORACEAE	Streblus asper						X	X								X	X												
MORINGACEAE	Moringa oleifera				X			X																					
MUSACEAE	Musa spp.			X	X								X			X				X			X	X					
MYRISTICACEAE	Horsfieldia iryaghedhi							X																					
MYRISTICACEAE	Myristica dactyloides							X																					
MYRISTICACEAE	Myristica fragrans						X																				X		
MYRSINACEAE	Maesa perrottetiana																X												
MYRTACEAE	Eucalyptus sp..	X	X																										

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MYRTACEAE	Eugenia sp.				X																								
MYRTACEAE	Pimenta dioica						X																						
MYRTACEAE	Psidium cattleyanum																										X		
MYRTACEAE	Psidium guajava			X																									
MYRTACEAE	Syzygium aromaticum						X	X		X																		X	
MYRTACEAE	Syzygium cordifolium																										X		
MYRTACEAE	Syzygium cumini	X	X	X				X																					
MYRTACEAE	Syzygium gardneri																										X		
MYRTACEAE	Syzygium jambos			X																	X								
MYRTACEAE	Syzygium makul			X																							X		
MYRTACEAE	Syzygium operculatum			X																							X		
MYRTACEAE	Syzygium umbrosum																										X		
NYCTAGINACEAE	Bougainvillea sp.														X														
NYCTAGINACEAE	Mirabilis jalapa							X																					
OXALIDACEAE	Averroha carambola			X				X																					
OXALIDACEAE	Averrohoa bilimbi			X			X																						
OXALIDACEAE	Biophytum reinwardtii							X									X												
OXALIDACEAE	Oxalis corniculata							X									X												
OLEACEAE	Jasminum sambac														X														
OLEACEAE	Nyctanthes arbor-tristis														X								X						

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ORCHIDACEAE	Anoectochilus regalis							X																					
ORCHIDACEAE	Vanilla planifolia						X																					X	
PALMAE	Areca catechu	X	X					X	X				X					X	X	X			X	X	X				
PALMAE	Calamus sp.												X									X							
PALMAE	Caryota urens	X	X		X	X		X	X			X	X			X									X				
PALMAE	Cocus nucifera	X	X	X	X	X			X	X	X	X	X			X			X	X		X	X	X					
PALMAE	Corypha umbraculifera										X		X										X	X					
PALMAE	Elaeis guineensis									X																			
PALMAE	Loxococcus rupicola				X				X																		X		
PALMAE	Phoenix dactylifera														X														
PANDANACEAE	Pandanus sp.						X																						
PASSIFLORACEAE	Passiflora sp..			X		X																							
PEPEROMIACEAE	Peperomia pelucida																X												
PETIVERIACEAE	Rivina humilis																X												
PETTIVERIACEAE	Petiveria alliacea																X												
PIGMONEACEAE	Spathodea campanulata		X																										
PINACEAE	Pinus carebaea	X	X																										
PIPERACEAE	Piper betle							X	X														X	X					
PIPERACEAE	Piper chawya							X																					
PIPERACEAE	Piper longum							X																					
PIPERACEAE	Piper nigrum						X	X																				X	
PIPERACEAE	Piper sylvestre																										X		
PIPERACEAE	Piper umbellatum																										X		

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PITTOSPORACEAE	Pittosporum ceylanicum	X	X																									
PLUMBAGINACEAE	Plumbago indica							X																				
POLYPODIACEAE	Drymoglossum heterophyllum							X																				
POLYPODIACEAE	Nephrolepis veralla														X													
PROTEACEAE	Grevillea robusta	X	X															X	X									
PTEROPHYTIMA	Lycopodium sp..														X													
PTEROPHYTINA	Adiantum caudatum							X									X											
PTEROPHYTINA	Asplenium sp.														X		X											
PTEROPHYTINA	Drycanopteris linearis																X										X	
PTEROPHYTINA	Pteris biaurita														X		X											
PTEROPHYTINA	Pteris longifolia														X		X											
PUNICACEAE	Punica granatum			X				X							X													
RHAMNACEAE	Ventilago maderaspatana										X						X											
RHAMNACEAE	Zizyphus sp..																X											
RHIZOPHORACEAE	Carallia brachiata	X	X																									
RUBIACEAE	Adina cordifolia	X	X					X																				
RUBIACEAE	Coffea arabica		X			X		X																			X	
RUBIACEAE	Coffea liberica		X			X		X																			X	
RUBIACEAE	Coffea robusta		X			X		X																			X	
RUBIACEAE	Hedyotis auricularia							X									X											
RUBIACEAE	Hedyotis fruticosa							X									X											
RUBIACEAE	Hedyotis nitida							X									X											
RUBIACEAE	Ixora arborea														X													

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RUBIACEAE	Ixra coccinea							X							X								X						
RUBIACEAE	Knoxia zeylanica																X												
RUBIACEAE	Morinda citrifolia				X			X															X						
RUBIACEAE	Mussandra frondosa				X										X														
RUBIACEAE	Ophiorrhiza mungos							X									X												
RUBIACEAE	Ophiorrhiza mungos							X									X												
RUBIACEAE	Pavetta indica							X																					
RUBIACEAE	Wendlandia bicusspidata		X														X												
RURACEAE	Murraya paniculata																										X		
RUTACEAE	Achronychia pedunculata		X					X													X								
RUTACEAE	Acronychia pedunculata							X													X								
RUTACEAE	Aegle marmelos			X				X						X															
RUTACEAE	Atalantia sp.							X															X						
RUTACEAE	Chloroxylon swietenia	X	X																										
RUTACEAE	Citrus acidus			X																									
RUTACEAE	Citrus aurantifolia			X				X																					
RUTACEAE	Citrus aurantium			X				X																					
RUTACEAE	Citrus limon			X																									
RUTACEAE	Citrus medica							X																					
RUTACEAE	Citrus reitculata			X																									
RUTACEAE	Citrus sinensis			X				X																					
RUTACEAE	Clausena indica							X																					

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RUTACEAE	Feronia limonia		X	X				X															X						
RUTACEAE	Glycosmis mauritiana																										X		
RUTACEAE	Glycosmis pentaphylla							X																					
RUTACEAE	Micromelum ceylanicum							X																					
RUTACEAE	Murraya koenigii						X	X																					
RUTACEAE	Ruta graveolens							X							X														
RUTACEAE	Ruta graveolens							X																					
RUTACEAE	Toddalia asiatica							X									X												
SAMBUCUACEAE	Sambucus sambac														X			X							X				
SANTALACEAE	Santalum album							X		X																			
SAPINDACEAE	Allophyllus cobbe							X																					
SAPINDACEAE	Cardiospermum halicacabum							X																					
SAPINDACEAE	Filicium decipiens	X	X												X														
SAPINDACEAE	Harpullia arborea	X	X																										
SAPINDACEAE	Lepisanthes tetraphylla																X												
SAPINDACEAE	Lepisanthes trichocarpa																X												
SAPINDACEAE	Nephelium lappaceum			X																									
SAPINDACEAE	Nephelium longana	X	X	X																									
SAPINDACEAE	Schleichera oleosa	X	X	X				X																					
SAPOTACEAE	Madhuca longifolia	X	X	X				X		X								X											
SAPOTACEAE	Manilkara zapota	X	X	X																									
SAPOTACEAE	Mimusops elengi			X				X																					

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SAPOTACEAE	Pouteria campechiana			X																								
SCHIZAEAZEAE	Lygodium sp..												X				X											
SCROPHULARIACEAE	Bacopa monniera							X																				
SELAGINELLACEAE	Selaginella sp..														X													
SIMAROUBACEAE	Ailanthus triphysa							X																				
SMILACEAE	Smilax zeylanica							X									X											
SOLANACEAE	Cestrum elegans							X							X													
SOLANACEAE	Datura suaveolens							X																				
SOLANACEAE	Lycopersicon esculentum				X																							
SOLANACEAE	Solanum xanthocarpum				X																							
SOLANACEAE	Solanum indicum				X			X																				
SOLANACEAE	Solanum melongana				X			X																				
SOLANACEAE	Solanum melongena							X																				
SOLANACEAE	Solanum virginianum																X											L
SOLANACEAE	Solanum nigrum																X											
SOLONACEAE	Capsicum annuum						X																					
STAPHYLEACEAE	Turpinia malabarica	X																										
STERCULIACEAE	Theobroma cacao			X		X	X																				X	
STERULIACEAE	Melochia corcherifolia																X											
STERULIACEAE	Melochia umbellata																X											

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SYMPLOCACEAE	Symplocos spicata							X					X		X														
SYMPLOCAEAE	Symplocos cochinchinensis							X																X					
SYMPLOCAEAE	Symplocos racemosa																X												
THEACEAE	Camelia sinensis		X			X																					X		
THYMELAECEAE	Wikstroemia canescens																										X		
THYMELEACEAE	Gyrinops walla							X																					
TILIACEAE	Berrya cordifolia	X	X																	X									
TILIACEAE	Grewia microcos																										X		
ULMACEAE	Celtis cinnamomea							X																					
ULMACEAE	Trema orientale																												
UMBELLIFERAE	Centella asiatica				X			X																					
UMBELLIFERAE	Hydrocotyle javanica							X																					
URTICACEAE	Fleurya interrupta																X												
VERBENACEAE	Callicarpa tomentosa								X												X								
VERBENACEAE	Clerodendrum infortunatum							X									X												
VERBENACEAE	Clerodendrum serratum							X																					
VERBENACEAE	Gmelina asiatica							X																					
VERBENACEAE	Lantana camara			X													X												
VERBENACEAE	Phyla nodiflora																												
VERBENACEAE	Stachytarpheta indica																X												

FAMILY	SPECIES	T	F	Fr	V	B	S	M	St	O	Ta	Fi	To	G	Or	Fo	W	So	R	Wr	P	Ty	R	C	Fe	D	U	C	L
VERBENACEAE	Stachytarpheta urticifolia																X												
VERBENACEAE	Tectona grandis	X	X																										
VERBENACEAE	Vitex negundo							X															X		X				
VERBENACEAE	Vitex altissima	X																											
VITACEAE	Cissus quadrangularis							X																					
VITACEAE	Vitis vinifer							X																					
VITACEAE	Cissus trilobata																X												
ZINGIBERACEAE	Costus speciosus					X		X									X												
ZINGIBERACEAE	Curcuma longa						X	X																X					
ZINGIBERACEAE	Curcuma oligantha							X																X					
ZINGIBERACEAE	Curcuma zedoaria							X																					
ZINGIBERACEAE	Elletaria cardamomum						X																				X		
ZINGIBERACEAE	Kaempferia rotunda							X																					
ZINGIBERACEAE	Languas galanga							X																					
ZINGIBERACEAE	Zingiber cylindricum																X												
ZINGIBERACEAE	Zingiber officinale						X	X																					
ZINGIBERACEAE	Zingiber zerumbet							X																					

LIST OF BIRD SPECIES FOUND IN THE *GEWATTA* SYSTEM

CROWS AND MAGPIES	*CORVIDAE*
Black Crow	*Corvus macrorynchos culminatus*
House Crow	*Corvus splendens protegatus*
TITS	*PARIDAE*
Ceylon Grey Tit	*Parus major mahrattarum*
NUTHATCHES	*SITTIDAE*
Velvet-fronted Blue Nuthatch	*Sitta frontalis frontalis*
BABBLERS	*TIMALIDAE*
Common Babbler	*Turdoides striatus striatus*
Ceylon Rufuous Babbler	*Turdoides rufescens*
Ceylon Scimitar Babbler	*Pomatorhinus horsfieldii*
Brown-capped Babbler	*Pellorneum fuscocap. fuscocapillum*
Black-fronted Babbler	*Rhopocichla atriceps nigrifrons*
BULBULS	*PYCNOTIDAE*
Ceylon Iora	*Aegithina tiphia multicolor*
Gold-fronted Chloropsis	*Chloropsis aurifons insularis*
Jerdon's Chloropsis	*Chloropsis jerdoni*
Ceylon Black Bulbul	*Microscelis psaroides*
Red-vented Bulbul	*Molpastes cafer cafer*
Yellow-browed Bulbul	*Iole icterica*
Black-capped Bulbul	*Pycnonotus melaniceterus*
Ceylon White-browed Bulbul	*Pycnonontus luteolus insulae*
CHATS, ROBINS, AND THRUSHES	*TURIDAE*
Ceylon Black Robin	*Saxicoloides fulicata leucoptera*
Southern Magpie Robin	*Copsychus saularis ceylonensis*
FLYCATCHERS	*MUSCICAPIDAE*
Ceylon Orange-breasted Blue Flycatcher	*Muscicapa tickelliae neseaea*
Brown Flycatcher	*Muscicapa latirostris*
Indian Paradise Flycatcher	*Tchitrea paradisi paradisi*
Ceylon Paradise Flycatcher	*Tchitrea paradisi ceylonensis*
White-browed Fantail Flycatcher	*Leucocirca aureola compressirostris*
WARBLERS	*SYLVIIDAE*
Hume's Whitethroat	*Sylvia althaea*
Green Tree Warbler	*Phylloscopus trochiloides nitidus*
Greenish Tree Warbler	*Phylloscopus trochiloides viridanus*
Ceylon Tailor-bird	*Orthotomus sutorius sutorius*

SHRIKES	*LANIIDAE*
Brown Shrike	*Lanius cristatus cristatus*
MINIVETS AND CUCKOO-SHRIKES	*CAMPEPHAGIDAE*
Orange Minivet	*Pericrocotus flammeus*
Ceylon Little Minivet	*Pericrocotus peregrinus ceylonensis*
Black-headed Cuckoo Shrike	*Coracina sykesi*
DRONGOS	*DICRURIDAE*
Ceylon Common Drongo	*Dicrurus caerulescens leucopygialis*
ORIOLES	*ORIOLIDAE*
Ceylon Black-headed Oriole	*Oriolus xanthornus ceylonensis*
GRACKLES	*EULABETIDAE*
Common Grackle	*Eulabes religiosa indica*
STARLINGS AND MINAHS	*STURNIDAE*
Ceylon Common Mynah	*Acridotheres tristis melanosternus*
WEAVERS, MUNIAS AND SPARROWS	*PLOCEIDAE*
Baya Weaver	*Ploceus philippinus philippinus*
Black-headed Munia	*Munia malacca*
White-backed Munia	*Urolоncha striata striata*
Spotted Munia	*Urolоncha punctulata lineoventer*
Ceylon House Sparrow	*Passer domesticus sorror*
WHITE EYES	*ZOSTEROPIDAE*
Ceylon Small White-eye	*Zosterops palpebrosa egregia*
SUNBIRDS	NECTARINIIDAE
Loten`s Sunbird	*Cinnyris lotenia lotenia*
Purple Sunbird	*Cinnyris asiatica asiatica*
Purple-rumped Sunbird	*Cinnyris zeylonica zeylonica*
FLOWERPECKERS	*DICAEIDAE*
Ceylon Small Flowerpecker	*Dicaeum erythrorhynchos ceylonensis*
Legge`s Flowerpecker	*Dicaeum vincens*
PITTAS	*PITTIDAE*
Indian Pitta	*Pitta brachyura*
WOODPECKERS	*PICIDAE*
Ceylon Red-backed Woodpecker	*Brachypternus bengh. erithronotus*

BARBETS	*CAPITONIDAE*
Brown-headed Barbet	*Thereiceryx zeylanicus zeylanicus*
Yellow-fronted Barbet	*Cyanops flavifrons*
Ceylon Small Barbet	*Xantholaema rubicapilla rubicapilla*
KINGFISHERS	*ALCEDINIDAE*
Ceylon Commoan Kingisher	*Alcedo atthis taprobana*
Ceylon White-breasted Kingfisher	*Halycon smyrnensis fusca*
HORNBILLS	*BUCEROTIDAE*
Ceylon Grey Hornbill	*Tockus gingalensis*
CUCKOOS, MALKOHAS, AND COUCALS	*CUCULIDAE*
Koel	*Eydynamys scolopaceus scolopaceus*
Common Coucal	*Centropus sinensis parroti*
PARAKEETS AND THE LORIKEET	*PSITTACIDAE*
Ceylon Large Parakeet	*Psittacula eupatria eupatria*
Rose-ringed Parakeet	*Psittacula krameri manillensis*
Blossom-headed Parakeet	*Psittacula cyanocephala cyanocephala*
Emeral-collared Parakeet	*Psittacula calthorpae*
Ceylon Lorikeet	*Loriculus berryllinus*
OWLS	*STRIGIDAE*
Brown Wood Owl	*Strix leptogrammica orchrogenys*
Ceylon Little Scops Owl	*Otus scaps leggei*
Collared Scops Owl	*Otus bakkamoena bakkamoena*
VULTURES, EAGLES, HAWKS	*ACCIPITRIDAE*
And Their Allies,	
Ceylon Serpent Eagle	*Spilornis cheela spilogaster*
Brahminy Kite	*Haliastur indus indus*
Ceylon Shikra	*Accipiter badius badius*
PIGEONS AND DOVES	*COLUMBIDAE*
Pompadour Green Pigeon	*Treron pompadora pompadora*
Ceylon Orange-brested Green Pigeon	*Treron bicincta leggei*
Ceylon Bronze-wing Pigeon	*Chalcophaps indica robinsoni*
Ceylon Spotted Dove	*Streptopelia chinensis ceylonensis*

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