Journal for Nature Conservation 12 (2004) 181—189

Available online at www.sciencedirect.com

SCIENCE DIRECT®

Journal for Nature Conservation

www.elsevier.de/jnc

New options for land rehabilitation and landscape ecology in Southeast Asia by "rainforestation farming"

Friedhelm Göltenboth[a,*], Claus-Peter Hutter[b]

[a]*University of Hohenheim, Institute for Plantproduction and Agroecology in the Tropics and Subtropics, Garbenstr. 13, D-70593 Stuttgart, Germany*
[b]*EURONATUR, Bahnhofstr. 35, D-71638 Ludwigsburg, Germany*

Received 4 March 2003; accepted 14 March 2004

KEYWORDS
Landscape ecology;
Resource management;
Reforestation;
Philippines

Summary

Continental and insular Southeast Asia were originally endowed with vast areas of luxurious Tropical Evergreen Forest. Mainly since the sixties of the last century these tropical rainforests have been under a steadily increasing pressure due to intensive logging for commercial purposes and the increasing number of people depending on the given environment for more agricultural land and for fuel wood.

One innovative approach to combine the necessities of rural development, safe natural resource management and biodiversity restoration was developed under the acronym "Rainforestation Farming" on the island of Leyte in the Philippines. More than 100 different local forests and fruit tree species were tested and planted in a near-to-nature planting scheme concerning species composition in a former degraded area covered by *Imperata cylindrica*.

The recommended planting scheme includes both sun-requiring trees and shade-loving trees, highly valuable timber trees and fruit trees. During the first year of planting, nursery grown sun-loving trees were planted at close distance of 2×2 m to quickly reach the condition of a closed canopy and therefore shading out of the grass. During the second year, shade-loving trees, coming from either the nursery or from the natural forest in the form of seedlings sitting under mother trees, were planted under the established first year pioneers.

To support the protection of the remaining forest, particularly the mother trees as resource for seedlings and to spur biodiversity rehabilitation efforts through people's participation a support system with community organisers was established. Already after four years some highly endangered species like the herbivorous Flying Lemure,

*Corresponding author. Tel.: +81-75-961-3171; fax: +81-75-962-9690.
E-mail address: friedgoelten@gmx.de (F. Göltenboth).

1617-1381/$ - see front matter © 2004 Elsevier GmbH. All rights reserved.
doi:10.1016/j.jnc.2004.03.003

Gynocephalus volans, and the insectivorous nocturnal ape, *Tarsius syrichta*, moved back into parts of the reforested closed canopy areas of the research and model farm.
© 2004 Elsevier GmbH. All rights reserved.

Introduction

The archipelago of tropical Southeast Asia is one of the richest concerning biodiversity from a global perspective. Unfortunately the unique fauna and flora is under a steadily increasing threat by land use systems like ecologically unsafe logging practices, expansion of monocultures in the form of tree- and agricultural crop plantations, shifting cultivation and an increasing demand of a growing population for land.

In particular the Tropical Evergreen Lowland Rainforest disappears at a very alarming rate due to the increasing demand for valuable tropical hardwood species belonging to the family of Dipterocarpaceae. This ecosystem with its enormous variety of biotopes and biocoenosis influences the productivity and services provided by ecosystems. The variety of species in an ecosystem changes the ecosystem's ability to absorb pollution, to maintain soil fertility and micro-climates, cleanse water, provide options for new components of medicinal value, and other invaluable services. The value of variety is particularly apparent in agriculture. For generations low-input production systems produce a wide range of crops and livestock contributing to adequate watershed protection, maintenance of soil fertility and integrated pest-management strategies in a local context.

As biodiversity is so closely intertwined with human needs, its conservation should rightfully be considered of highest priority (Haeruman, 1993). While some reduction in biodiversity has been an inevitable consequence of human development, today many areas that have been cultivated traditionally for centuries are becoming degraded agricultural and biological ''green deserts'' and need to be classified as highly critical land. Rural poverty, greed and gross neglect of basic ecological principles have reduced the former Tropical Evergreen Lowland Rainforest areas to sometimes mere decorative patches of ecologically useless stands of remnant forests. Such overuse and misuse not only disrupts ecosystem function and drives many species into extinction but it also imposes costs and threats.

From the decade of the 60s to the late 80s of the last century, rapid forest depletion swept through the tropics in the name of development. Vast primary forest areas throughout Southeast Asia were routinely cleared with sometimes very destructive methods to give way to other land use activities. The adverse effects like increased frequency of floods in lowlands, erosion on large scale in the uplands, sedimentation of rivers, reservoirs, lakes and coral areas occurred in catastrophic proportions. But even dramatic events like the inferno-like forest fires that swept through thousands of hectares of primary forest in Kalimantan and Sumatra in 1997–1998 have only led to hesitant reactions.

Traditional nature conservation was based on the paradigma to protect nature entirely from the impacts of development. Today the biodiversity conservation approach differs from traditional nature conservation, because it shifts from a defensive posture to an offensive effort seeking to meet peoples' needs from biological resources while ensuring the long-term sustainability of biotic wealth. A number of countries in Southeast Asia have imposed logging bans, like Thailand and the Philippines, and at the same time it was realised that in many parts of the world centralised government management has widely failed to maintain the economic productivity and ecological sustainability of their forest resources (Sarin, 1995). In a sometimes frantic search for remedies and alternatives the rediscovery of the positive effects of communally administered forests led to the lesson that community-based forest management is a suitable and effective strategy towards forest conservation and sustainable development. A change from forest-based industrialisation to participatory or local community-based rural development by tree-farming with a special emphasis on local or indigenous tree species is a more suitable option for combining three major necessities: Sustainable rural development, conservation of remaining primary forests and biodiversity rehabilitation.

Efforts to preserve and rehabilitate the biodiversity and simultaneously sustain human food production and income generation on the subsistence level, led to the development of a ''closed canopy and high diversity forest farming system, called rainforestation farming'' on Leyte in the Philippines during the 1990s. This system replaces the slash and burn practices, protects biodiversity, helps to re-establish the ecological functions of a given ecosystem and provides subsistence farmers

with a stable and long-term income (Margraf & Milan, 1996; Göltenboth, 1999; Schulte, 2002). Contrary to the conventional paradigmas of farm and forest management the "rainforestation farming system" works with the hypothesis that "a farming system in the humid tropics is increasingly more sustainable the closer it is in its species composition to the original local rainforest" (Milan & Margraf, 1994).

During the last three decades the original amount of 17 million ha of remaining forested area in the Philippines was reduced by mainly disastrous logging and land use practices to about 5.5 million ha (Fig. 1). The resulting, sometimes catastrophic, consequences, like the flash flood in Ormoc City on Leyte where about 8000 people died in one night in 1991, forced the government to impose a total logging ban, in place since 1990. Further, the steadily growing population pressure, political and economic instability turned vast areas of the mid-mountain regions into squatter settlements based on slash and burn subsistence (Figs. 2 and 3). This leads to an expansion of mainly *Imperata cylindrical* grasslands and highly eroded slopes, particularly in the mid-mountain region, a prolongation of the list of endangered endemic species and increased economic poverty in rural areas. The depression of the yield of old stands of coconut plantations, covering more than 2 million ha, and the drastically dropping prices for copra accelerated the poverty process. Neglect of the plantation areas and increasing use of coconut lumber without any replanting efforts is leading to even more serious ecological consequences as already faced by the logging of the rainforest. Therefore urgent contributions and actions are needed to alleviate the growing poverty in rural areas leading to a steadily increasing migration of the rural poor to the cities, a decrease in the exploitation pressure on the remaining ecosystem, prevention of further large-scale soil erosion, landslides, floods and near coast coral reef sedimentation, particularly during rainy seasons and provide local biodiversity a chance for rehabilitation by re-establishing near-to-nature, appropriate agriculturally used man-made habitats.

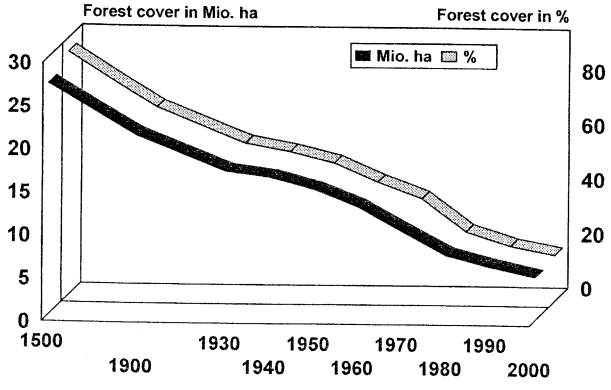


Figure 1. Reduction of forest cover in South East Asia (after DENR, 1990; Uitamo, 1996; Schulte, 2002).

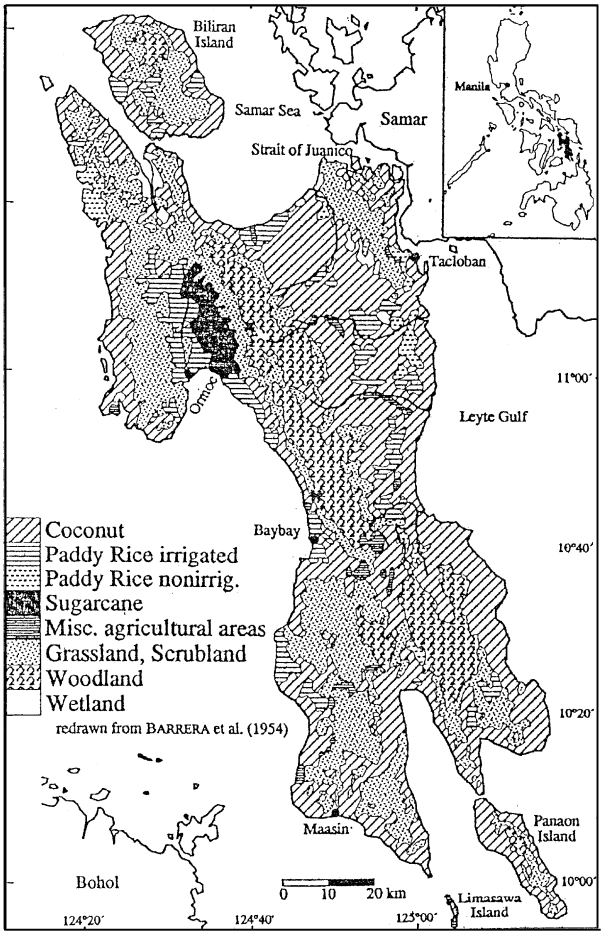


Figure 2. Land use systems on the Island of Leyte, Philippines (Source: GPS Unit ViSCA, Leyte, Philippines 1998).

Methods in "rainforestation farming"

The following principle approaches and methods were used:

Basic studies of the ecological functions of the given environment including biodiversity studies and socio-economic baseline data collection of the people living in the region resulted in numerous research studies and other publications (Margraf & Milan, 1991, 1996; Engler, 1992; Klee, 1992; Grüninger, 1993; Balzer, 1993; Balzer & Margraf, 1994; Dargantes & Koch, 1994; Diputado, Briones, & Dialimas, 1994; Denzer, Henle, Gaulke, Margraf,

& Milan, 1994; Belonias & Banoc, 1994; Quimio, 1994; Schütz, 1994; Widmann, 1994; Müller-Edzard, 1994; Asio, 1995; Cenizia, 1995; Dargantes, 1996; Waibel, Wessler, & Dirksmeyer, 1997; Widmann, 1998; Fessel & Balzer, 1999; Göltenboth & Göltenboth, 2000; Schoppe, 2000; Schulte, 2002). Other components included the

- production of educational material,
- selection of the most recommendable forest tree species for first year and second year planting (Tables 1 and 2) in demonstration nurseries,
- establishment of mother tree protection schemes in the remaining rainforest areas mostly in the upper watersheds by training of community organisers,
- development of planting schemes on a 17ha model or demonstration farm and specifically selected other sites on different soils and in different altitude and exposure including sun-requiring trees, pioneer trees, fruit trees and rainforest trees in need for shade during their first years (Figs. 4 and 5),
- lobbying for appropriate tenant security schemes and land ownership rights, including the right to harvest planted trees, and
- developing alternative livelihood activities during the initial phase of the transitional phase from slash-and-burn-based agriculture into tree-farming-based agriculture.

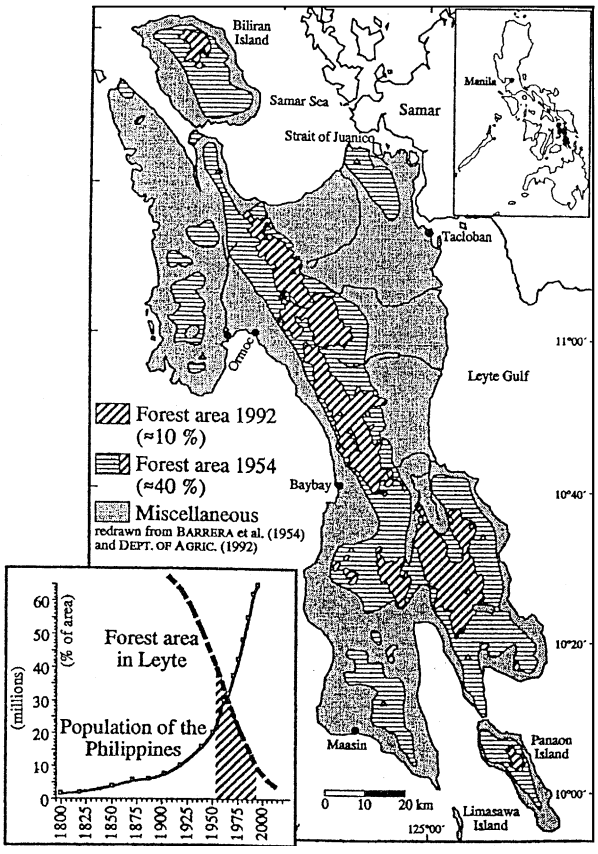


Figure 3. Comparison of the forest areas on the island of Leyte, Philippines between 1954 and 1992 and population increase (Source: GPS Unit ViSCA, Leyte, Philippines 1998).

After the first year of planting of sun requiring trees at a close distance of 2×2 m and initial weeding the system could be left alone until the second year planting of shade-loving tree—seedlings. The narrow distance-planting scheme closes the canopy fast with the effects that the bole growth is straight and the grass is shaded out rapidly. Second year trees, mainly Dipterocarpaceae species do grow straight through the overlaying canopy and through careful thinning a three-storey structure can be achieved (Fig. 6). The close-to-nature grouping of the trees reduces the competitiveness for resources and helps to avoid

Table 1. Twelve sun demanding local forest tree species of Leyte on volcanic soils (after Schulte, 2002)

Scientific name	Family	Ecology and status
Dracontomelon dao	Anacardiaceae	Vanishing
Koordersiodendron pinnatum	Anacardiaceae	Widespread but depleted
Rademachera pinnata	Bignoniaceae	Widespread
Afzelia rhomboidea	Leguminosae	Liable to genetic erosion
Intia bijuga	Leguminosae	Threatened with extinction
Terminalia catappa	Combretaceae	Widespread
Disospyros blancoi	Ebenaceae	Widespread
Pterocarpus indicus	Leguminosae	Disappearing in nature
Melia dubia	Meliaceae	Depleted
Toona sureni	Meliaceae	Endangered
Artocarpus communis	Moraceae	Widespread fruit tree
Eucalyptus deglupta	Myrthaceae	From sea level to 1800 m

Table 2. Twelve examples of shade loving local forest tree species of Leyte on volcanic soils (after Schulte, 2002)

Scientific name	Family	Ecology and status
Agathis philippinensis	Araucariaceae	Very rare
Anisoptera thurifera	Dipterocarpaceae	Depleted
Dipterocarpus grandiflorus	Dipterocarpaceae	Common in some areas
Hopea accuminata	Dipterocarpaceae	Widespread, common
Hopea plagata	Dipterocarpaceae	Widespread
Parashorea malaanonan	Dipterocarpaceae	Prone to genetic erosion
Shorea alamon	Dipterocarpaceae	Depleted
Shorea asamica	Dipterocarpaceae	Widespread
Shorea contorta	Dipterocarpaceae	Widespread
Shorea negrosensis	Dipterocarpaceae	Widespread
Shorea palosapis	Dipterocarpaceae	Widespread
Shorea polysperma	Dipterocarpaceae	Widespread

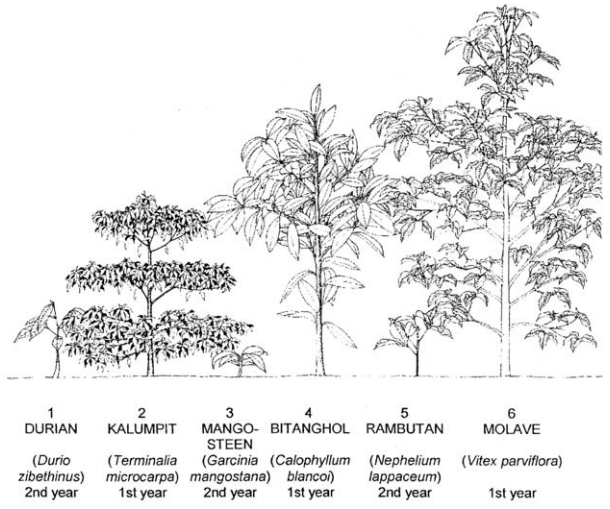


Figure 4. Indigenous rainforest trees in combination with shade loving fruit trees (after Margraf & Milan, 1996).

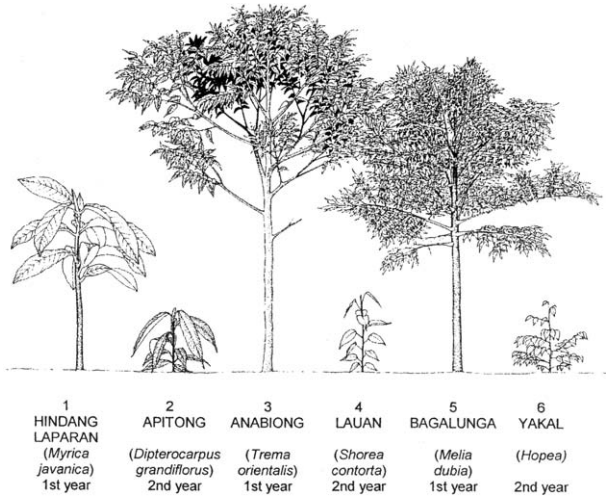


Figure 5. Indigenous sun loving pioneer trees in combination with shade demanding hard wood lumber trees (after Margraf & Milan, 1996).

outbreaks of pests. If farm products are to be included, as recommended, a system from conventional sun-demanding crops to shade tolerant crops such as *Discorea* spp., *Colocasia* spp., *Xanthosoma* spp. and particularly *Musa textiles* in combination with ornamental plants like orchids, anthurium, aroids and zingibers should be followed. After about 4–5 years the income of the farmers had already increased by about 8%, particularly through the selling of low-quality timber of the pioneer species and from first fruit harvests and after about 12 years it can be expected that the income from quality timber species will provide a sustainable high income (Fig. 7).

Results and discussion

Environmental considerations

From an environmental and biodiversity aspect this technology alleviates pressure on both biotope and biocoenosis because highly degraded areas are revaluated as income generating areas while at the same time the biodiversity is enriched through creation of new niches for the indigenous fauna and flora. From this aspect, the strict rule to only use indigenous trees in the scheme is of crucial importance. In particular, the upper parts of watersheds play a prominent role in providing all the essential ecological functions keeping the middle- and lowlands as well as the coastal areas intact as major productive areas for the rural population, whether working as farmers or as fishermen. Therefore, any major disturbance in these key areas will directly influence the livelihood and existence of these people. Reforestation efforts are urgently needed in these upper and mid-mountain areas, implemented in a way that the

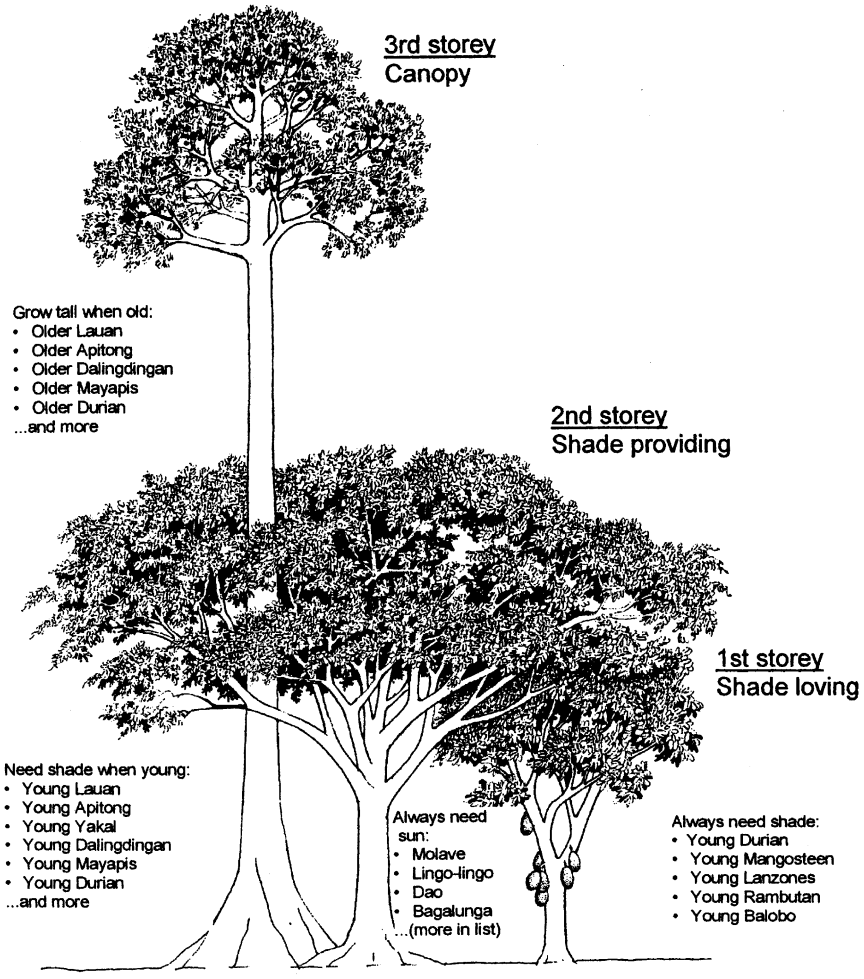


Figure 6. A 3-storey tree farm structure as result of the "rainforestation farming" approach (after Margraf & Milan, 1996).

rural subsistence farmers and coastal fisher-folks are beneficiaries while at the same time the local biodiversity is supported. Biodiversity protection is achieved mainly in three ways:

1. Actively through the propagation and planting of endangered tree species in a near-to-nature planting scheme.
2. Passively through the creation of suitable habitat and microclimate to which the species migrate from adjacent secondary growth areas.
3. By efforts to protect the remaining mother-trees, which are the producers of seeds needed for the nurseries.

Socio-economic considerations

Usually people have no concept of exhaustion and replacement of natural resources. They do not realise that even trees, unless replaced by man or nature, are a non-renewable resource. The general notion is that man can always go to the forest and forever cut trees without the need to replenish and maintain it until no substantial forest is left. Therefore high priority must be given to combine all reforestation efforts with educational measures at all levels. The local communities and the decision-making ranks of the political elite need to be confronted with the realities, reasons and their consequences. Similarly, all parties need to be involved in the solution finding processes from the very beginning. Of utmost importance is the realisation that the rural poor living near a forested area will only involve themselves in conservation efforts, including reforestation, if they receive benefit whether economically, politically or in status. These kind of socio-economic aspects are a key-issue and if handled in an appropriate bottom-up approach could lead to initiatives and activities by local communities and co-operations becoming officially recognised active protectors in

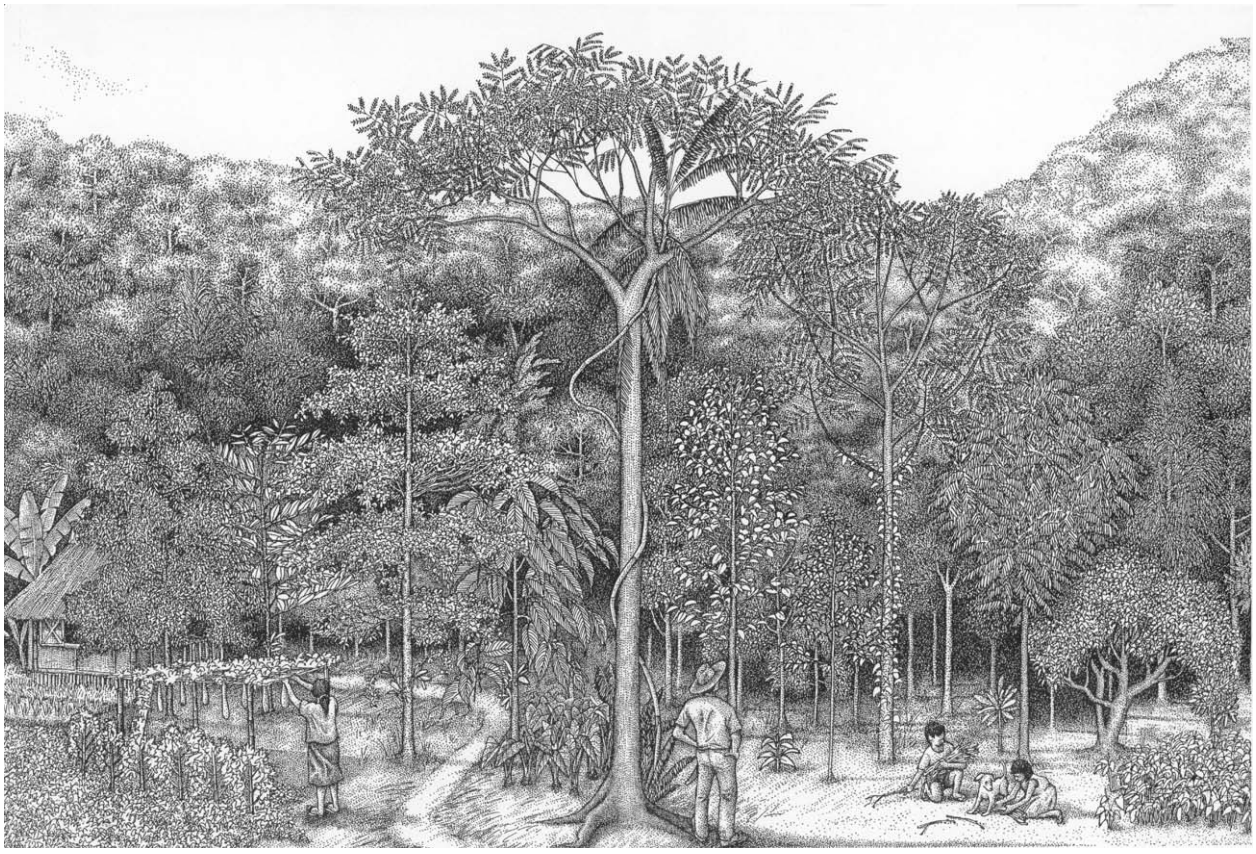


Figure 7. Idealised view of subsistence "rainforestation farm" after about 12–15 years (after Margraf & Milan, 1996).

their respective watersheds. This protection role could involve policing to protect mother trees, from where they get their seedlings, bringing illegal loggers to court, starting innovative activities like eco-tourism, providing services to plantation owners in gradually transforming their old coconut stands into highly valued timber land, even making a successful business with the tree seedlings raised in their community-based nurseries on the local markets and offering their training services to other farmer- and community groups.

Sustainability considerations

"Rainforestation farming technology" was gradually developed. In an attempt to combine the essential elements of forest and food production systems the following preliminary working hypothesis guided the initial research: "The closer a farming system in the humid tropics is to a natural rainforest ecosystem, the more sustainable it is." Due to the basic research concerning local forest biodiversity and its interrelationship with the surrounding farming system, including socio-economic research this preliminary working hypothesis was reformulated as follows: "The closer a farming system in the humid tropics is to a natural rainforest ecosystem in its physical structure, the more efficiently can it maintain its ecosystem functions."

Certainly irrigated rice fields have to be excluded from this hypothesis. They are, by their aquatic nature, more sustainable as they function as nutrient traps, provide efficient nutrient cycling within a highly diverse aquatic biocoenosis and offer a sustainable environment for efficient nitrogen fixation (Milan & Margraf, 1994).

Singularities of the local climate need also to be addressed, because local species are more adjusted to these dramatic events, e.g. typhoons or El Nino Southern Oscillation (ENSO) effects. The working hypothesis was therefore developed further to its present version: "A farming system in the humid tropics is increasingly more sustainable the closer it is in its species composition to the original local rainforest" (Milan & Margraf, 1994).

Experience in the field shows that farmers and landowners of worn-out coconut plantations easily recognise the economic potential of the "rainforestation farming system". More often it is the conventionally thinking administrator and forest

department bureaucrat who cause set-backs. In reforestation efforts, emphasis remains on exotic "miracle trees" like *Gemelina arborea*, *Acacia mangium*, and *Eucalyptus* spp. for large scale reforestation. If sustainable land use is to go hand-in-hand with the protection of forest biodiversity and management for income generation on degraded areas, flanking environmental education based on hands-on activities is obligatory.

The "rainforestation farming technology" provides an opportunity to generate income out of an area that is usually no longer economically productive, while at the same time producing timber of high value, providing protection of the land and rehabilitating and conserving the local biodiversity.

However, this scheme has to be attuned to the local situation and communities. It should be the farmers' choice to either select single elements of the "rainforestation farming system" or to combine it with the compartmentalisation of the land use system familiar to them. In the Philippines, one of these systems is the production of natural fibres coming from *Musa textilis* growing well under shade conditions. There are highly promising aspects that this natural fibre could be used in relevant industries, including the car industry due to its very good mechanical properties (Fig. 8).

The "rainforestation farming technology" allows for the reforestation of degraded areas and worn-out plantations with a highly diverse and economically future-oriented, sustainable tree farm. This system is feasible for many areas throughout Southeast Asia after adaptation to the local environment and situation. The implementation of this technology is therefore a substantial contribution to stop the ongoing destruction of remaining primary forests by desperate rural farmers, to rehabilitate degraded rural environments and give rural people a perspective of a sustainable income to sustain their subsistence on a generation scale.

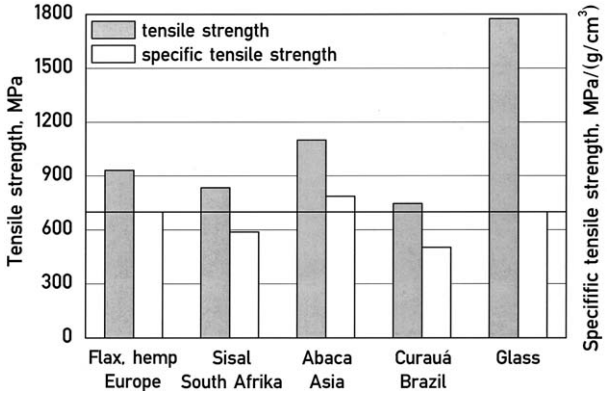


Figure 8. Comparison of tensile strength and specific tensile strength of various natural fibres and fiberglass (after Schlösser & Mühlbauer, Internal Report, Daimler-Chrysler 2002, unpublished).

During a ten years model phase in the form of a bilateral project supported by the Philippine and German Governments, and continued on various levels by EURONATURE (Germany), the University of Hohenheim (Germany) and the Leyte State University (Philippines), the following three major goals could be achieved:

- Establishment of community-based "closed canopy and high diversity farming systems", called "rainforestation farming" in former degraded areas.
- Provision of a sustainable income for the families of the rural subsistence farmer involved, whether as single farmers or organised in co-operatives.
- Protection and rehabilitation of the environment and biodiversity as demonstrated by the return of endangered wildlife into areas of "rainforestation farming", like the smallest, and highly endangered, ape *Tarsius syrichta*.

References

Asio, V. (1995). *Genesis and degradation of soils under different land uses in leyte*. Ph.D. thesis. Stuttgart, Germany: University of Hohenheim.

Balzer, P. (1993). *Untersuchungen zur Mikroflora von sechs Standorten auf der Insel Leyte*. M.Sc. thesis. Stuttgart, Germany: Univerity of Hohenheim.

Balzer, P., & Margraf, J. (1994). Recent rainfall trends in ViSCA, Baybay, Leyte. *Annals of Tropical Research, 16*(4), 33–42. ViSCA, Baybay, Philippines.

Belonias, B. S., & Banoc, L. M. (1994). Species diversity and distribution of pteridophytes in Mt. Pangasugan. *Annals of Tropical Research, 16*(2), 30–38. ViSCA, Baybay, Philippines.

Cenizia, J. M. C. (1995). Arthropod abundance and diversity in different ecosystems of Mt. Pangasugan, Baybay, Leyte, Philippines with special reference to coleoptera and hymenoptera fauna. *PLITS*, Vol. 13(3). Stuttgart: W. & S. Koch Verlag.

Dargantes, B. B. (1996). Socio-ecological case studies on forest lands cultivation in Leyte, Philippines. *PLITS*, Vol. 14(2), Stuttgart: W.& S. Koch Verlag.

Dargantes, B. B., & Koch, W. (1994). Case studies on the occupation and cultivation of the forest lands of Leyte, Philippines. *Annals of Tropical. Research, 16*(2), 13–29. ViSCA, Baybay, Philippines.

DENR (1990). *Master plan for forestry development*. Quezon City, Philippines: Department of Environment and Natural Resources.

Denzer, W., Henle, K., Gaulke, M., Margraf, J., & Milan, P. (1994). Annotated checklist of the reptiles and

amphibians of Leyte, Philippines, with notes on their ecology and conservation. *Annals of Tropical Research*, *16*(4), 44–70. ViSCA, Baybay, Philippines.

Diputado, M. T., Briones, E. D., & Dialimas, R. D. (1994). Distribution of aranoids and epiphytes in Mt. Pangasugan ecosystems according to elevation. *ViSCA-GTZ Terminal Report*, ViSCA, Baybay, Philippines, p. 44.

Engler, A. (1992). *Ökologische Untersuchungen zur Arthropodengemeinschaft auf Süsskartoffeln in Abhängigkeit von der Umgebungsvegetation auf der Insel Leyte, Philippinen*. M.Sc. thesis. Stuttgart, Germany: University of Hohenheim.

Fessel, H. H., & Balzer, P. (1999). *A selection of native Philippine orchids*. Singapore: Times Editions.

Göltenboth, F. (1999). Rainforestation Farming—an innovative approach for sustainable land use and biodiversity conservation in the Philippines (pp. 3–16). EcoSys, Suppl. Bd, 28, Kiel, Germany.

Göltenboth, F., & Göltenboth, A. (2000). Agro-ecological comparison of "rainforestation" farming sites on Leyte, Philippines. *Proceedings Dt. Tropentag 2000* (pp. 84–85). University of Hohenheim, Stuttgart, Germany.

Grüninger, M. (1993). *Agrarökologische Untersuchungen zur Homopteren- und Hymenopterenfauna verschiedener Maniok-Anabausysteme auf der Insel Leyte, Philippinen unter besonderer Berücksichtigung der Mottenschildlaus Aleyrodicus dispersus Russel (Homoptera: Aleyrodidae)*. M.Sc. thesis. University of Hohenheim, Stuttgart, Germany.

Haeruman, H. (1993). *Biodiversity Action Plan for Indonesia*. Jakarta: Ministry of National Development Planing.

Klee, R. (1992). *Untersuchungen zur Segetalflora im Süsskartoffelanbau der Insel Leyte, Philippinen*. M.Sc. thesis. University of Hohenheim, Stuttgart, Germany.

Margraf, J., & Milan, P. (1991). Endangered freshwater fish communities of Leyte Rivers, Philippines. *Proceedings of the international conference on conservation. and management of tropical inland waters: Problems, Solutions and Prospects*. Hong Kong.

Margraf, J., & Milan, P. (1996). Ecology of lowland evergreen forests and its relevance for island Rehabilitation on Leyte, Philippines. In A. Schulte, & D. Schöne (Eds.), *Lowland evergreen forest ecosystems* (pp. 124–154). Singapore: World Scientific.

Milan, P., & Margraf, J. (1994). Rainforestation Farming: An alternative to conventional concepts. *Annals of Tropical Research*, *16*(4), 17–27. Visayas State College of Agriculture, Baybay, Leyte, Philippines.

Müller-Edzard, C. (1994). *Untersuchungen zur Artenzusammensetzung, Häufigkeitsverteilung und Grössenklassenzusammensetzung verschiedener Gehölzarten auf 2 × 0.5 ha Primärwald am Mt. Pangasugan, Leyte, Philippines*. M.Sc. thesis. University of Bayreuth, Bayreuth, Germany.

Quimio, C. A. (1994). Bryophytes of river valleys and kaingin areas of Mt. Pangasugan, Leyte, Philippines. *Annals Trop. Res*, *16*(2), 28. ViSCA, Baybay, Philippines.

Sarin, M. (1995). Joint Forest Management in India: Achievements and un-addressed challenges. *Unasyslva*, Vol. 4(180). Rome: FAO.

Schoppe, S. (2000). *Echinoderms of the Philippines*. Singapore: Times Editions.

Schulte, A. (2002). *Rainforestation Farming: Option for rural development and biodiversity conservation in the humid tropics of Southeast Asia*. Aachen, Germany: Shaker Verlag.

Schütz, P. (1994). *Zur Bedeutung von Schwärmern (Sphingidae, Lepidoptera) bei der Bestäubung von Frucht- und Forstbäumen in Agroforestry-Systemen auf Leyte, Philippinen*. M.Sc. thesis. University of Hohenheim, Stuttgart, Germany.

Uitamo, E. (1996). Land use history in the Philippines. In M. Palo, & G. Mery (Eds.), *Sustainable forestry challenges for developing countries* (pp. 141–156). Kluwer Academic: Doordrecht, Netherlands.

Waibel, H., Wessler, J., & Dirksmeyer, W. (1997). The economics of reforestation farming. In J. Margraf, F. Göltenboth, & P. Milan (Eds.), *Proceedings of international conference reforestation with philippine species for biodiversity protection and economic progress* (pp. 286–301). Philippines: Palo, Leyte.

Widmann, P. (1994) .*Zur Bedeutung der Flughunde (Pteropodidae) bei der Bestäubung in Agroforestry-Systemen auf Leyte, Philippinen*. M.Sc. thesis. University of Hohenheim, Stuttgart, Germany.

Widmann, P. (1998). *A guide to the ecosystems of Palawan*. Singapore: Times Editions.