„Rainforestation“ farming for biodiversity conservation and rural development in the Philippines

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Abstract

Besides the Amazon Basin the archipelagic region of South East Asia is one of the richest areas of this globe concerning biodiversity. The tropical forest, coastal and marine ecosystems of the islands of South East Asia are under a steadily increasing threat due to a population increase and unsound economic developments not in balance with the carrying capacity of the given ecosystems.
Hand in hand with the destruction or depletion of the various ecosystems the rich fauna and flora with an unusually high degree of endemism is pushed nearer and nearer to the boundary of extinction for many of its most valuable and often even scientifically unknown species.
During an eight year bilateral project in the Philippines on the island of Leyte rehabilitation technologies have been developed to either enrich or reforest depleted or degraded former forest land by farmers and farmer cooperatives under the assumption that „ a farming system in the humid tropics becomes increasingly more sustainable the nearer it is in its species composition and physical structure to the local rain forest ecosystem“ (Milan and Margraf, 1994). By following this assumption it was possible to show that conservation and rehabilitation of the local biodiversity and sustainable economical development in rural areas of the Philippines is not a contradiction.
The technologies which were developed under the acronym of „Rainforestation“ Farming and the research results which will be presented combine possibilities of sustainable rural development, biotope and biocoenosis protection.

Introduction

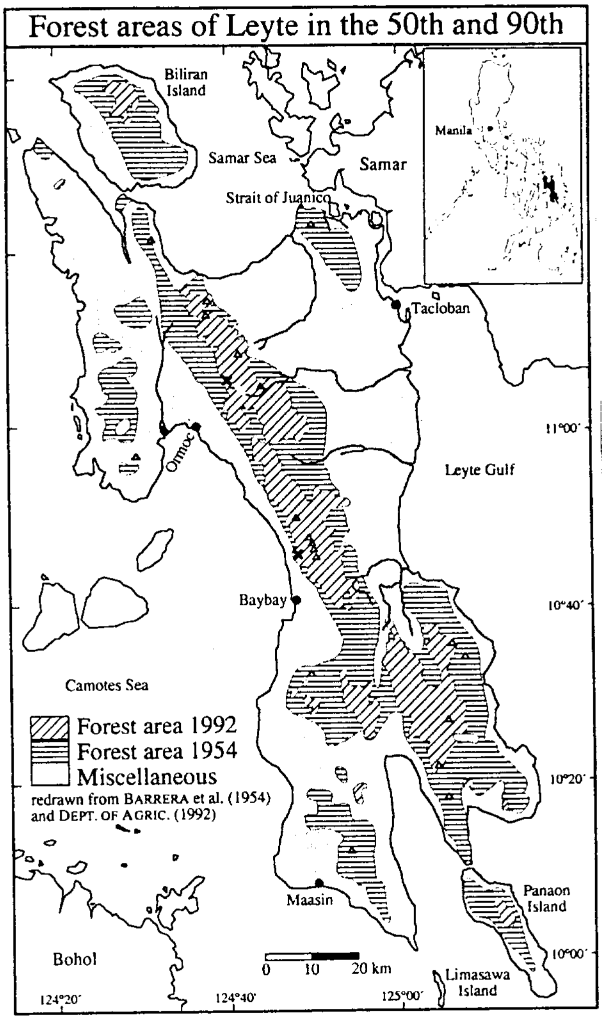
From both wild and domesticated components of biodiversity humanity derives all of its food and many medicines and industrial products. The sheer variety of life has enormous value, because the variety of distinctive species, biotopes and biocoenosis influences the productivity and services provided 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, and provide other invaluable services. The value of variety is particularly apparent in agriculture. For generations low-input production systems produced 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. Biodiversity being the totality of genes, species and ecosystems in a region, provides a momentum in the constant evolutionary battle between crops and livestock and the pest and diseases that prey on them. The unknown potential of genes, species and ecosystems represents a never-ending

biological frontier of inestimable but certainly high value, a resource that can be tapped as human needs and demands change.
As biodiversity is so closely inter-winded with human needs, its conservation should rightfully be considered an element of highest priority (Haeruman, 1993).
While some reduction in biodiversity has been an inevitable consequence of human development, as species-rich forests and wetlands have been converted to relatively species-poor farmlands and plantations, today more and more ecosystems are converted to impoverished systems that are less productive-economically as well as biologically. Such misuse not only disrupts ecosystem function, it also imposes costs and threats.
Biodiversity conservation differs from traditional nature conservation, because it shifts from a defensive posture- protecting nature from the impacts of development- to an offensive effort seeking to meet peoples' needs from biological resources while ensuring the long-term sustainability of biotic wealth.
These thoughts about sustaining human food production and simultaneously preserve the biodiversity of terrestrial ecosystems and their vital functions led to the development of a bilateral project on the island of Leyte in the Philippines since 1990 with the goal to improve the ecological conditions on Leyte in order to uplift the socio-economic life of the rural poor. This led to the development of a „Closed Canopy and High Diversity Forest Farming System“ otherwise known as „Rainforestation“ Farming after about 10 years.

Locality and Abiosis

The island of Leyte with about 6,300 km^2 is part of the Eastern Visayas , a central part of the archipelago of about 7,100 islands which form the Philippines. This island lost between 1969 and 1984 about 45% or 77,000 ha of its original forest cover thus reducing the forest cover to about 12.5% (Langenberger, 1999) (Fig 1).
It was calculated by the National Forest Management Bureau in 1987 that a pro capita forest cover of 0.3 ha is needed for the Philippines to satisfy the needs for wood products on a sustained base. For the island of Leyte this figure is presently 0.04 ha per head of the about 1.5 mio people living permanently on Leyte. Further the rich biodiversity is threatened by the destruction of habitats both terrestrial and marine and more and more species are at the brink of extinction. In 1995 about 62.5% of all bird species, 32.0% of all mammal species and 5.5 % of all reptilia were endangered or threatened on the Philippines. The main reason is the destruction of habitats, mostly of old growth forests (Malayang, 1997).
While between 1948 and 1982 an average of 5 typhoons in three years could be observed, the number of typhoons and flash floods in 1998 alone was more than five. These climatic events add further problems to the already existing ones in this region with average rainfall of about 2,600 mm and an average temperature of 27^{o}C. Landslides are common on Leyte due to the geologically young rugged relief , dominated by volcanic parent material for the generally wide spread, nutrient rich haplic Andosol (Andisol) and Alisol (Ultisol) soil coverage (Asio et al., 1998, Jahn and Asio, 1998). Certain limestone outcrops can be found in some parts of Leyte.
To stop the vicious cycles involved in man-made landscape destruction the Philippine government consequently imposed a total logging ban since the 90-ies and reforestation efforts have gained top priority.

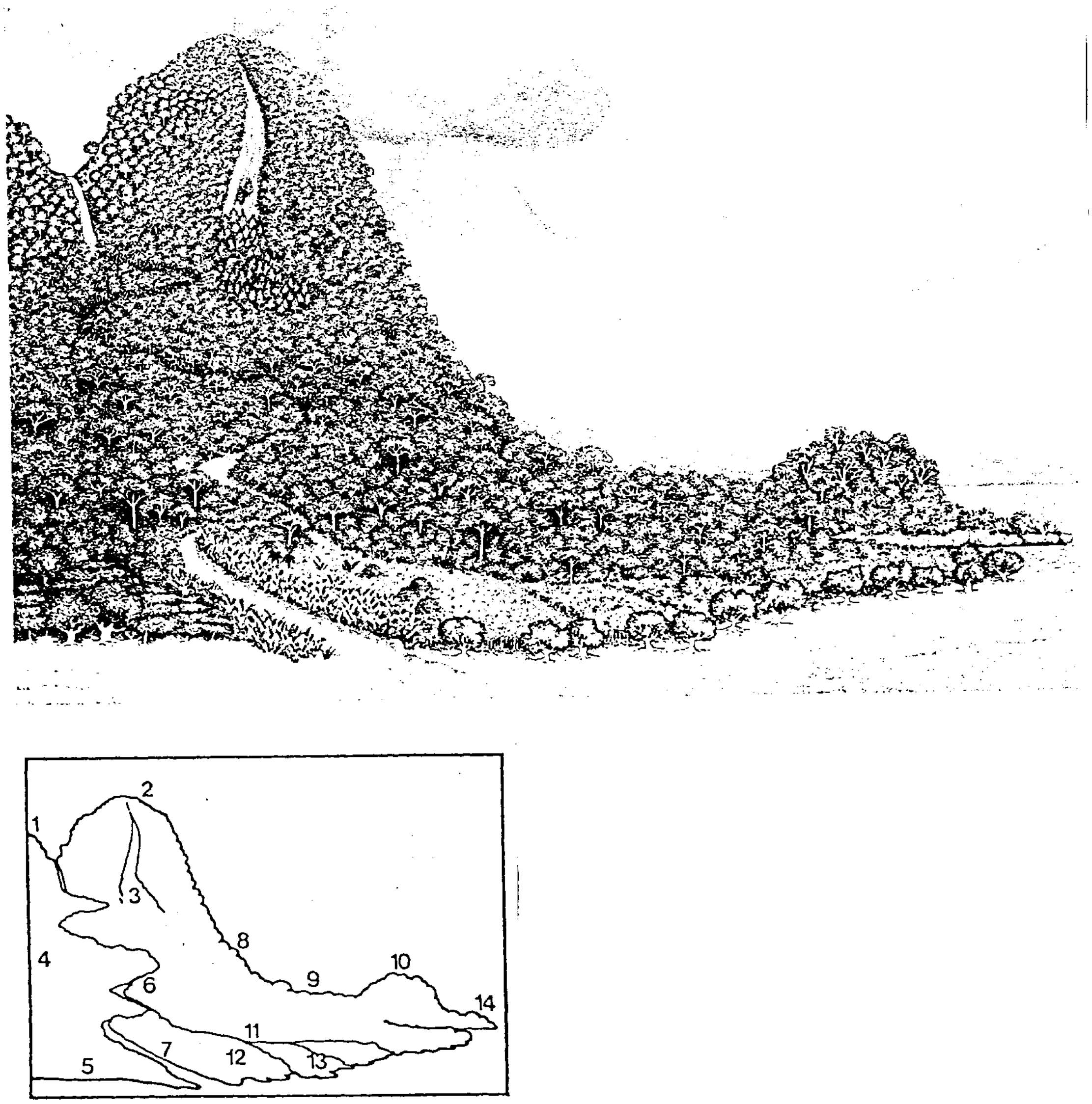
Figure 1. Comparison of the forested areas of Leyte in 1954 and 1992 (after GIS Unit ViSCA, Baybay 1998)



Major Biotopes and Biocoenosis of Leyte

Before the advent of the Spanish colonial time about 400 years ago the characteristic forest formations and vegetation types for the Philippines formed an uninterrupted belt from the mangrove and beach forest to mossy forest on the summits of the Leyte Cordillera with more than 1000 m a.s.l.(Weidelt and Banaag, 1982, Seeber et al. 1985, Langenberger, 1999 (Fig. 2).

Figure 2. Characteristic forest types and vegetation formations on Leyte, Philippines (after Margraf and Milan,1996).



1 Steep ravine and cliff forest, 2 Mossy Forest, 3 Landslide succession vegetation,
4 Mid-mountain *Pentacme-Dipterocarpus* dominated Forests, 5 Beach Forests,
6 Volcanic low hills *Hopea-Dipterocarpus* dominated Forests, 7 *Nypa*- Swamp Forest,
8 Mid-mountain *Shorea*-Oak dominated Forest, 9 Lowland *Pentacme* dominated Forest,
10 Forests over limestone or Molave Forest, 11 Lowland *Dipterocarpus* dominated Forests,
12 Freshwater swamp *Barringtonia* dominated forest, 13 Mangrove Forests,
14 Coastal Rock Vegetation.

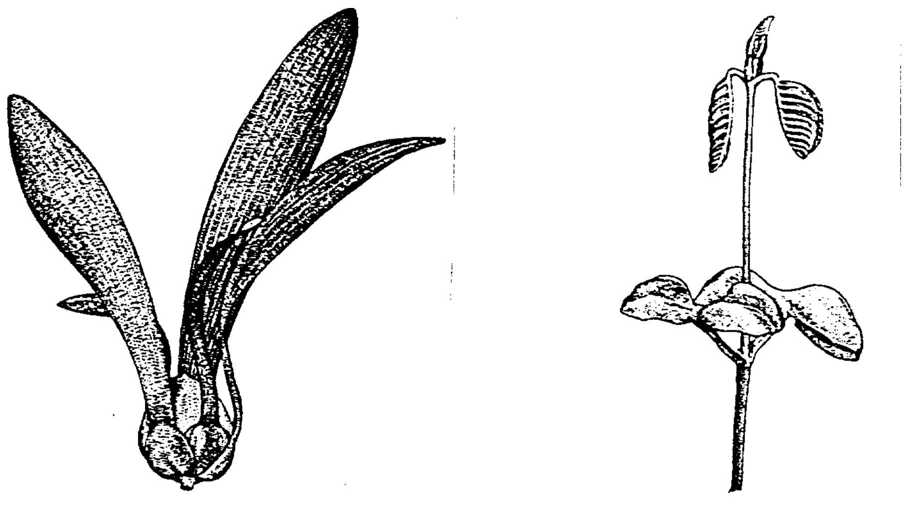
During the last 95 years the Philippines lost 15 million hectare of forest bringing down the forested area from about 21 million hectare in 1900 to less than 6 million in 1995 (Malayang, 1997). Today the forests up to 200-300 m a.s.l. have been replaced by various land use systems. The present land uses of the deforested areas in Leyte can be given as follows (Tab. 1).

Table 1. Land uses in Leyte Philippines in 1996 (after Asio et al., 1996).

Land Use	% of deforested area
Grassland and scrubland	60
Coconut plantations	33
Sugarcane Plantations	2
Irrigated Rice Fields	2
Non-irrigated Rice Fields	1
Miscellaneous agricultural areas	2

In general, after clear cutting of forest and repeated cultivation of root crops, abaca or fiber producing banana, banana, corn, coconut and use for livestock production, grasses occupy the degraded land. The analysis of grass communities dominated by *Chrysopogon acicularis, Imperata cylindrica, Axonopus compressus* and *Saccharum spontaneum* lead to different directions of succession depending on soils, disturbance history, slope, paucity in seed sources for vascular plants and lighting quality (Quimio and Reiff, 1995).
The remaining forest areas above 200-300 m altitude or in difficult accessible areas does not form a continous cover but is composed of a patchy mosaic of different successional stages. Further, timber poaching and shifting cultivation are steadily destroying the remaining natural vegetation. Therefore valuable seed producing mother trees in old growth forest are becoming rare, e.g. in the Mt. Pangasugan area only one *Shorea almon* mother tree is left (Fig.3).

Figure 3. Winged seed and seedling of *Shorea almon* (Dipterocarpaceae). Distribution throughout Borneo and from Luzon to Mindanao in the Philippines on mainly clay soils in hilly areas at low altitudes. The relatively fast growing tree can reach 70 m height with up to 160 cm dbh. Flowering is observed in March to April with fruiting in June -July (after Newman et al., 1996).



Nevertheless, *Shorea* species accounted in 1985 for 59% of the standing volume and for 79% of the volume above 55 cm dbh (Schade et al., 1987). No more recent data seem to be available. In the foothill area of Mt. Pangasugan (1100 m) 216 trees and shrub species were identified, belonging to 63 families, including the still second most prominent family of Dipterocarpaceae with 16 species (Langenberger, 1999). In 1985 Dipterocarpaceae were represented with a volume of 72% in old growth forest (Tab.2). In 1999 the five most prominent families in the forest areas of Mt. Pangasugan were the Euphorbiaceae (17 species) followed by the Dipterocarapacea (16 species), Rubiaceae (15 species), Moraceae (15 species) and Meliaceae (12 species).

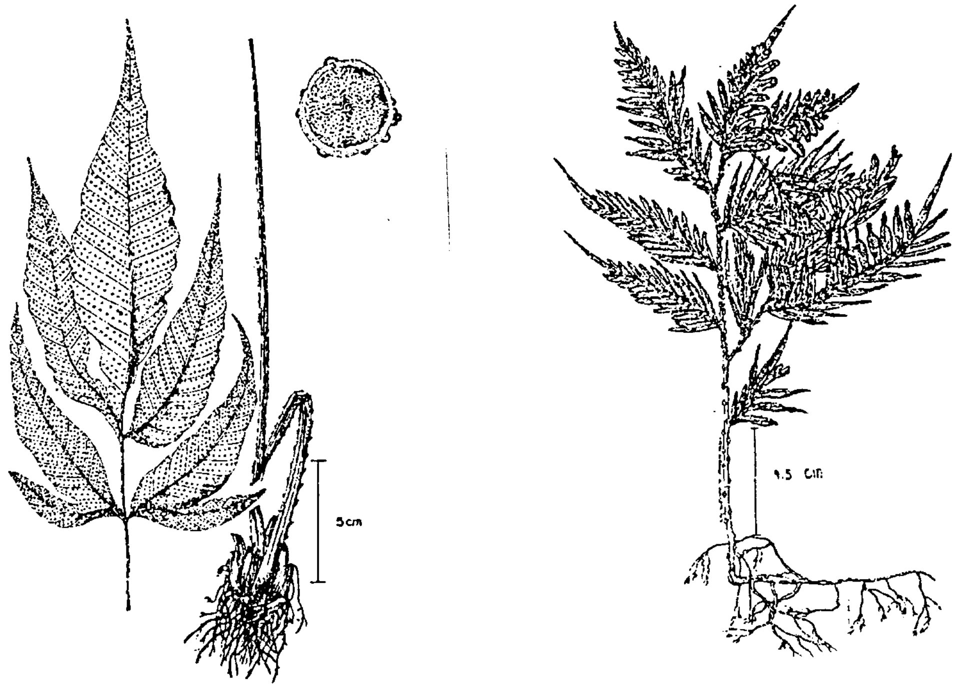
Table 2. The 10 most frequent tree families and tree species in primary forest areas of Leyte and Samar Island, Philippines (after Schade et al., 1987).
F % of sampling units with occurrence, N/ha Number of trees per hectare

Family/Species Name	F	N/ha
Dipterocarpaceae	**98.8**	**165.6**
Shorea squamata	90.2	46.7
Shorea negrosiensis	86.6	21.3
Shorea polysperma	84.1	28.5
Shorea almon	59.8	11.1
Vatica mangachapoi	39.0	4.2
Pentacme contorta	36.6	8.9
Myrtaceae	**68.3**	**27.8**
Cleistocalyx operculatus	45.1	12.3
Syzigium nitidum	39.0	9.6
Fagaceae	**50.0**	**19.3**
Lithocarpus ovalis	50.0	19.3
Myristicaceae	**43.9**	**13.5**
Myristica philippinensis	43.9	13.5
Dilleniaceae	**31.7**	**17.0**
Guttiferae	**31.7**	**12.2**
Sapotaceae	**29.3**	**9.6**
Burseraceae	**25.6**	**11.3**
Ebenaceae	**17.1**	**4.6**
Moraceae	**14.6**	**4.3**

Number of sampling units : 82; Standard error (%): 2.7; Inventory Period: 1986-87.

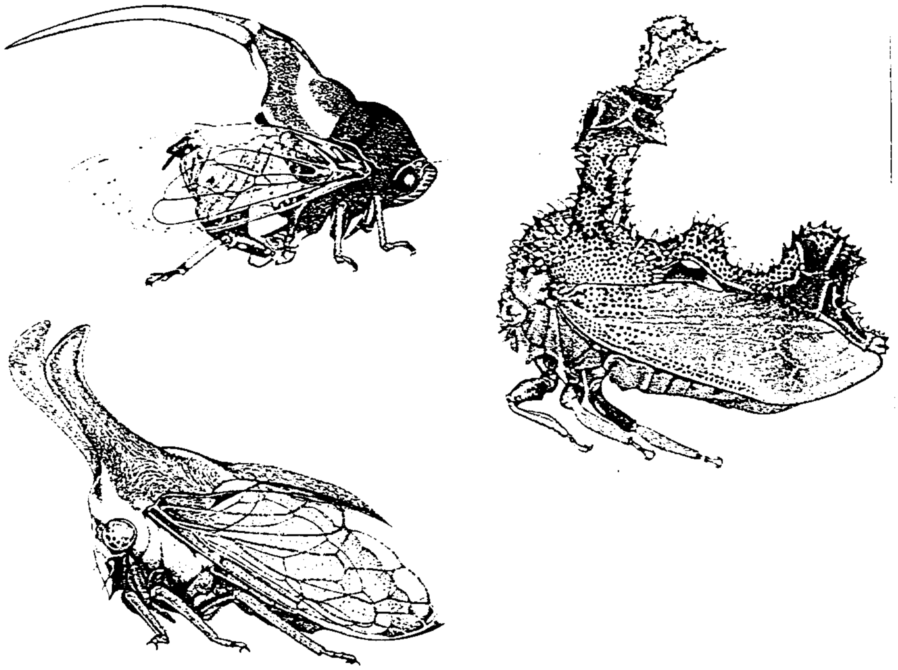
In addition to the counted and identified 208 species belonging to 63 tree and major shrub families still growing on the steep slopes of Mt. Pangasugan another 704 vascular plants were collected as associated flora belonging to 34 more families. 51 Bryophytes and Pteridophytes play an important role in soil formation and moisture retention of the forest system. For the various elevations from sea level to about 400 m a.s.l. more than 50 species of Bryophytes and more than 90 Pteridophytes were identified. The respective comparisons of the investigated elevations shows that species diversity is at a peak at 80 to 100 m a.s.l.(Fig.4)

Figure 4. The two most frequently occurring pteridophytes across elevation at Mt. Pangasugan, Leyte, Philippines : *Tectaria denticulata* (Burm.) Mett. (left) and *Selaginella engleri* Hieron (right)



At elevations from sea level to 350 m a.s.l. 25 species of aroids out of 12 genera have been collected. Climbers associated with trees belong mainly to the genera *Pothos, Philodendron, Scindapus*, *Epipremnum* and *Syngonium* (Diputado et al., 1994).
The high diversity of plants is only possible if the pollination and seed formation of the various species is efficient. In the case of the trees in tropical rainforests it is a well known fact that the number of individual species per hectare is low and the same species are usually spread over a large area. Therefore, far flying pollinators like Sphingidae or hawk moth and frugivore and nectivore bats play a crucial role not only as pollinators but, like in the case of the fruit bats, also as seed dispersers (Schütz, 1994, Widmann et al.,1995).
Arthropods occupy the majority of niches and show highest diversity in tropical rainforests compared with other faunal groups. Ants and termites are the most dominant arthropod groups on the forest floor and they are part of the consumer and the decomposer biocoenosis. Defence mechanisms to escape predation are widespread, including mimikry (Fig. 5).

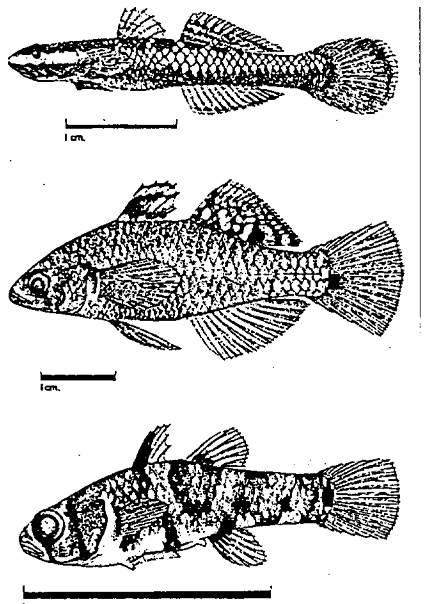
Figure 5. Three species of tiny homopterans of the family Membracidae showing various defense strategies to escape predation.



With 87 recorded terrestrial reptiles and amphibians the island of Leyte represents the highest known herpeto-amphibial faunal diversity of any island in South East Asia (Denzer et al., 1994).

In the many streams and rivulets of the various watershed areas no macrophytic primary producers are present. Therefore, the food chain of the lotic freshwater biocoenosis is based mainly on lithophytic algae and allochthonous organic matter. The leaves, flowers and fruits of forest plants are of crucial importance for the input of nutrients for the aquatic biocoenosis. Shredders like shrimps and prawns are abundant. More than 100 catadromous fish species are recorded for the lotic waters of Leyte. The majority of fish taxa belongs to the families of Gobiidae and Eleotridae (Fig. 6). The catadromous life cycle of the fish species is the optimal adaptation strategy for a region threatend by typhoons with catastrophic drift events down to the sea (Kottelat, 1993, Milan and Margraf, 1991).

Figure 6. Three fish species from lotic waters in Leyte. All three can be seen as bioindicators for respective stretches along intact streams.
Upper watershed areas or cascade zone: *Stiphodon artropurpureus* nov. spec.
Lower watershed areas or riverine zone: *Hypseleotris bipartita.*
Brackish water estuaries or brackish zone: *Pandaka trimaculata*

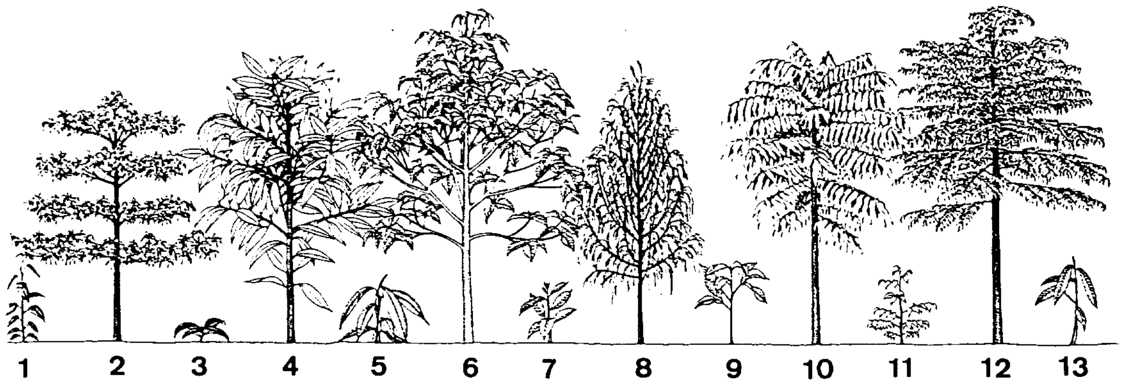


The destruction of the forested areas and the loss of their ecological functions is the main reason for the loss of biodiversity throughout the Philippines and the loss of prospects for a sustainable economical base for the present and future generations.
Without major efforts to rehabilitate and restore degraded areas and at the same time conserving the remaining forested areas in the given watersheds no such prospects are in sight.

“Rainforestation“ Farming Technologies

In 1992, the bilateral ViSCA-GTZ Applied Tropical Ecology Program started with a 4 ha demonstration farm and nursery to establish the „ Closed canopy and high diversity Forest Farming System“ with indigenous fruit- and rainforest trees. The working hypothesis , developed and refocused over several years according to the scientific findings about the working of the local biotopes and biocoenosis stated 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 and Margraf, 1994).
Tree species coming from the Dipterocarp forests, landslide successions, coastal forests and forests over limestone were screened for their applicability in the „rainforestation“ farming scheme. Nursing and planting schemes were developed using sun requiring trees first and shade loving trees planted under the established pioneers (Fig. 7).

Figure 7. Species combination with sun loving trees to be planted in the first year (tall trees) and shade loving fruit and timber trees for the second year of planting (small trees). Planting distance 2 x 2 meters.
1 *Hopea malibato;* 2 *Terminalia microcarpa;* 3 Mangosteen *Garcinia mangostana;* 4 *Calophyllum blancoi;* 5 *Dipterocarpus grandiflorus;* 6 *Vitex parviflora;* 7 *Dipterocarpus grandiflorus;* 8 *Casuarina nodiflora;* 9 Rambutan *Nephelium lappaceum;* 10 *Dracontomelon dao;* 11 *Pentacme contorta;* 12 *Melia dubia;* 13 Durian *Durio zibethus*



More than 120 different tree species were tested and about 31 sun loving pioneer forest trees and 20 shade demanding forest trees were selected and recommended as trees for „rainforestation“ farming schemes (Margraf and Milan, 1996). In addition 25 more forest trees are recommended for the „rainforestation“ farming system on Leyte after most recent screenings (Langenberger, 1999) (Tab. 3-4).

Table 3. The ten most recommendable tree species for first and second year planting in „Rainforestation“ farming according to their economic quality and site situation (after Margraf and Milan, 1996).

Scientific name	Family	Economic quality
First year : Sun demanding trees over limestone		
Artocarpus blancoi	Moraceae	all purpose; boats
Vitex parviflora	Verbenaceae	all purpose
Myrica javanica	Myricaceae	boats
Diospyros philippiensis	Ebenaceae	furniture
Intsia bijuga	Fabaceae	furniture
Ormosia calavensis	Fabaceae	furniture
Securinega flexuosa	Euphorbiaceae	construction
Terminalia microcarpa[1)]	Compretaceae	light construction
Melia dubia	Meliaceae	light construction
Securinega flexuosa[1)]	Euphorbiaceae	light construction

[1)]Fast growing, sun demanding local forest trees able to shade out weeds efficiently if planted in dense clusters

Second year: Shade demanding trees over deeply weathered, acid soils		
Forest Trees		
Anisoptera thurifera	Dipterocarpaceae	all purpose
Dipterocarpus validus	Dipterocarpaceae	all purpose
Parashorea malaanonan	Dipterocarpaceae	all purpose
Hopea acuminata	Dipterocarpaceae	heavy constructions
Hopea foxwothyi	Dipterocarpaceae	all purpose
Hopea malibato	Dipterocarpaceae	all purpose
Shorea almon	Dipterocarpaceae	heavy constructions
Shorea contorta	Dipterocarpaceae	all purpose
Shorea malibato	Dipterocarpaceae	heavy constructions
Castanopsis philippinensis	Fagaceae	furniture
Fruit Trees		
Durio zibethus	Bombaceae	highly priced fruit
Garcinia mangostana	Guttiferae	highly priced fruit
Nephelium lappaceum	Sapindaceae	highly priced fruit

Table 4. Recommended forest trees from various plant families (after Langenberger, 1999)

Scientific name	Family	Economic value
Albizia saponaria	Leguminosae	furniture
Diospyros pyrrhocarpa	Ebenaceae	furniture
Hopea plagata	Dipterocarpaceae	heavy construction
Shorea falciferoides	Dipterocarpaceae	heavy construction
Vatica mangachapoi	Dipterocarpaceae	heavy construction
Lophopetalum javanicum	Celastraceae	furniture
Marenthes corymbosa	Chrysobalanaceae	construction wood
Rheinwardtiodendron humile	Meliaceae	furniture
Tristania micrantha	Myrtaceae	heavy construction
Xanthostemon verdugonianus	Myrtaceae	heavy constructions
Koordersiodendron pinnatum	Anacardiaceae	furniture
Palaquium luzoniense	Sapotaceae	furniture
Garcinia benthami	Guttiferae	posts

The various research trials showed that before implementing the „Rainforestation“ Farming Technology the specific site conditions of a target area have to be carefully analysed. The microhabitat is important. If sites are dominated by grasses like *Imperata cylindrica* tree species who can outshade them efficiently and in a short time should be planted first (see Table 3).

Farming practices in tree-nursery-based subsistence farms

According to various studies (Waibel et al., 1986, 1997) the probability of a negative Net Present Value of the grassland-based „Rainforestation“ Farm is only 16%. This means under

the assumed distributions of the yield, price and cost variables it is unlikely that a parameter constellation occurs which turns „Rainforestation" Farming into an uneconomical venture (Waibel et al., 1997). However, as in any farming system aiming for timber production, the first years have to be supplemented by a production scheme where the traditional farming system is slowly fading out and the new system is gradually taking over to generate sufficient income for the farmer (Fig. 8.).
Therefore, the food production has to adjust to the changing conditions of the growing forested area. It is recommended that during the first years , when the pioneer trees are less than 2 meters in height, any sun demanding crop be planted. Later , the crops need to be changed to shade requiring species (Tab. 5) Ornamental plants, rattan and fiber-producing banana can be added to the scheme.

Figure 8. Costs, revenues and annual surplus of the grassland-based "Rainforestation" farming model farm (left) and the Coconut-based „Rainforestation" farm (right) (after Waibel et al., 1997)

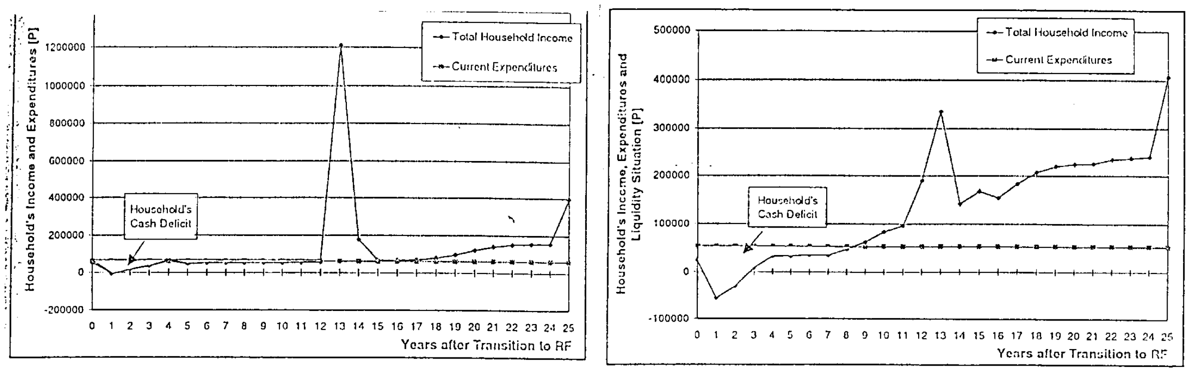


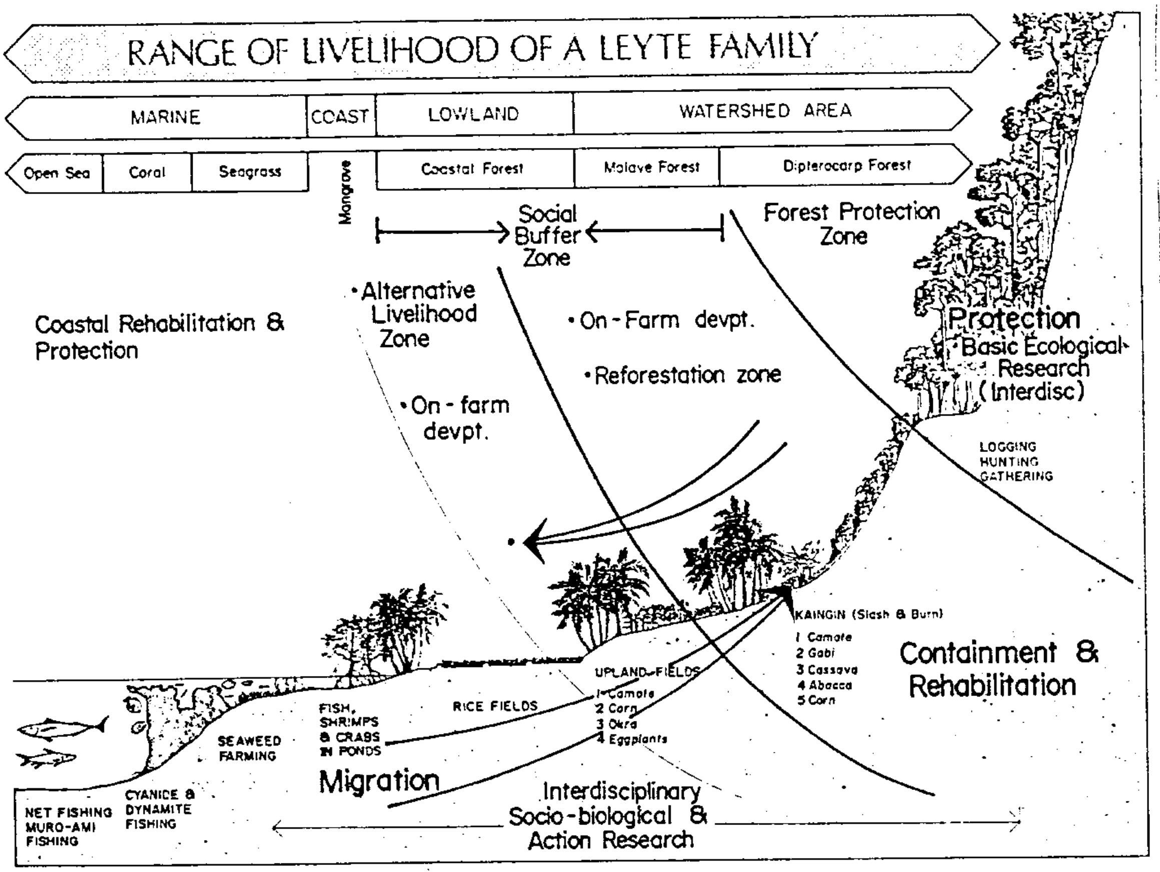
Table 5. Some of the recommended shade requiring plants for income augmentation in the first years of „Rainforestation" Farming (after Margraf et al.,1997).

Scientific name	Family	Comments
Food Crops		
Xanthosoma sagittifolium	Araceae	root crop, many varieties
Colocasia esculenta	Araceae	root crop, about 1000 varieties
Dioscorea bulbifera	Dioscoreaceae	aerial tubers, climber
Dioscorea alata	Dioscoreaceae	root crop, climber
Dioscorea eculenta	Dioscoreaceae	root crop, climber
Dioscorea pentaphylla	Dioscoreaceae	root crop, climber
Dioscorea rotundata	Dioscoreaceae	root crop, climber
Dioscorea trifida	Dioscoreaceae	root crop, climber
Curcuma angustifolia	Zingiberaceae	root crop
Spices, Dyes and Stimulants		
Zingiber officinalis	Zingiberaceae	ginger, many more species in use
Vanilla planifolia	Orchidaceae	climber
Curcuma domestica	Zingiberaceae	Yellow dye also for food (Tumeric)
Fiber Crops		
Musa textiles	Musaceae	about 100 varieties

Calamus sp.	Palmae	climber , many species
Ornamental crops		
A large number of orchids, aroids and Zingiber species of economic value as cut flowers or potted flowers.		

One of the most promising income generating activities is the selling of tree seedlings for the urban market, for reforestation schemes of the government and for reforestation of degraded areas of private enterprises.
It needs to be mentioned that on Leyte many rural households are not dependent only on one source of income but that the range of livelihood includes terrestrial and marine habitats (Fig. 9).

Figure 9. Conceptual view of the range of livelihood of a Leyte family and possible fields of activities and interventions (after Margraf and Milan, 1994).



Aspects of biodiversity conservation in „Rainforestation" Farms

The newly provided „closed canopy rainforestation farm" is relatively quickly re-colonized by the local fauna. The first to colonize reforested land are birds and fruit bats. Many of these species are carriers of seeds from other ecosystems and are such adding to the species community of trees and shrubs. Other species are long-distance pollinators. More than 30 bird species , belonging to 17 families were recorded from the 4-year-old „Rainforestation“ Farming Site at the Visayas State College of Agriculture (ViSCA). Fourteen of these bird species are known to be seed dispersers, five are pollinators and sixteen are insectivores. Seven bat species were recorded including frugivores, nectivores and insectivores. But not only animals that can travel long distances do come back to the provided new habitats but also such endangered and extremely rare mammals like the Philippine Tarsius, *Tarsius syrichta* (Margraf et al., 1997, Muehlbauer, 1999, pers. comm.).

Discussion and Conclusion

It is to expect that the Philippine primary forest will be further reduced by illegal timber poaching and extension of farming into forest areas. Only pockets of primary forest will be left in some inaccessible regions.

To save at least some of the very valuable Philippine forest tree species and therefore also their associated fauna and flora, the „Rainforestation“ Farming Technology could provide both, a sustainable income and the conservation and even restoration of some parts of the biodiversity.

Unfortunately in reforestation efforts emphasis is still on exotic „miracle trees“ like *Gmelina arborea, Acacia mangium, Acacia auriculiformis* and *Eucalyptus* spp. for large scale reforestation (Milan and Margraf, 1996).

The use of exotic trees contributes indirectly to deforestation, landslides and the drastic reduction of local biodiversity due to the following reasons:

- most of the fast growing exotics have low wood quality and therefore high quality timber from rainforest trees is still harvested.
- exotic tree species do not support the survival of local wildlife species, including important pollinators and seed dispersers.
- local farmers are dependent on seed and seedling distribution patterns not under their own control and local mother trees are not protected by them.
- growing exotic trees, mainly in monocultures supports a management of repeated clear-cutting in areas prone for typhoons and landslides.

The use of the Rainforestion Farming Technologies allows reforestation of degraded areas and old coconut plantations with a highly diverse and economically future-oriented tree - based farm.

If a system of balanced fading out of the presently existing land use and a fading in into a tree-oriented farming system is achieved the preservation of nature with her ecosystem functions and the stabilization of a good farming income might both be achieved.

Adjustments are certainly needed as well as a steady refocusing on the respective local situation. It should therefore be the farmer’s choice to select single elements of the rainforestation farming scheme to combine it with the compartimentalization of the agricultural system familiar to them.

Since 1994 twenty two „Rainforestation“ Farming sites are using the technologies on about 24.4 ha on various locations throughout Leyte with more than 20 000 trees planted. Some more sites are on the islands of Palawan, Bohol and Mindanao. Some of the farmers and farmers cooperatives are successfully generating substantial income from selling tree seedlings. The Department of Environment and Nature Resources (DENR) recognized the respective activities and issued certificates for the planted trees to ensure the right to harvest these trees in the future and submitted even policing power to some of the cooperatives in form of a kind of Stewardship Certificate or Community-based Forest Management

Agreement (CBFMA) to ensure the protection of the watershed areas in the vicinity of these „Rainforestation“ Farming cooperatives.

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