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**Structure and Processes in Traditional Forest
Gardens of Central Sulawesi, Indonesia**

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1 Introduction and basic conditions

1.1 Problem statement

According to the latest figures of the FAO (2003), the decline of the forest areas in tropical regions averaged 12.3 million ha per year in the period from 1990 to 2000. In Indonesia alone, the loss of forests amounted to 1.3 m ha or 1.2% of the total forest area per year in the same period. Between 1985 and 1997 Sulawesi lost 20% of its natural forest cover (Holmes 2000). One of the major causes for the decline of forest areas is the conversion of forest into other forms of land use, e.g. agriculture. On the other hand, huge areas of land in Indonesia are unproductive, e.g. *Imperata* grassland or degraded secondary forests. Agroforestry systems are an option to bring such unproductive land back under cultivation and thus also take the pressure from natural forests. Forest gardens, as one example of an agroforestry system, also offer an alternative to the conversion of forests by combining agricultural use with the preservation of a forest-like character. While agroforestry did not start to become popular until a few years ago, forest gardens have a long tradition in Sulawesi. The famous natural scientist Alfred Russel Wallace described forest gardens on his visit to Celebes (former name for Sulawesi) in 1856: “Some of the villages [...] are scattered about in woody ground, which has once been virgin forest, but of which the constituent trees have been for the most part replaced by fruit trees, and particularly by the large palm, *Arenga saccharifera*, from which wine and sugar are made” (WALLACE 2000). Fruit trees and the sugar palm (formerly: *Arenga saccharifera*, now: *A. pinnata*) are still the most important components of forest gardens in Central Sulawesi today.

To promote forest gardens as an apparently stable and sustainable land use system, it is necessary to learn more about their structure, dynamics and management. While these interrelations are well researched in forest gardens in other parts of Indonesia, little is known so far about forest gardens in Central Sulawesi.

With funding from DFG (Deutsche Forschungsgemeinschaft), the Collaborative Research Centre (SFB) “Stability of Rainforest Margins” (STORMA) was established in 2000. A major objective of this SFB was to study factors that influence the stability

of rainforest margins in Central Sulawesi. Preliminary investigations showed that the rainforest margin in the study area is a mosaic of primary and secondary forests, interlinked with different types of land use systems, and that forest gardens play an important role in this mosaic, forming the transition zone from natural forests to agricultural land. The study on hand, drawn up in project D1 of the SFB, aims to analyse the role of forest gardens for the stability of rainforest margins in Central Sulawesi.

1.2 Present state of research

1.2.1 Forest gardens in Asia

To avoid any confusion or lack of clarity, the terms “agroforestry“ and “forest gardens” are to be defined in the following section: according to NAIR (1989), “agroforestry is a collective name for land use systems in which woody perennials are deliberately grown in the same piece of land as agricultural crops and/or animals, either in some form of spatial arrangements or in sequence”. Forest gardens are consequently one type of agroforestry. In NAIR’s classification (1989), forest gardens can be categorized as “multilayer tree gardens”. The deciding criterion for the definition of forest gardens in this study was the prevailing forest-like character of the stands, with a high basal area, high number of trees, high tree species diversity and a high proportion of tree species from the natural forest.

The “International Centre for Research in Agroforestry” (ICRAF) carried out a world-wide inventory of the existing agroforestry systems (Agroforestry System Inventory, AFSI) from 1982 to 1987. In the course of that inventory, data from more than 150 agroforestry systems, including many forest gardens, were assessed and collected. Many forest gardens in Asia are well researched and documented in publications, e.g. the “Gewatta” or “Kandyan” systems in Sri Lanka (HOCHEGGER 1998, JACOB and ALLES 1987). Particularly many publications exist about forest gardens in Indonesia. The most important of them are listed in Table 1.

Table 1: Overview of forest gardens in Indonesia.

Name of system	Location	Dominant tree species	Described by (year)
<i>Shorea javanica</i> gardens (“Kebon damar”)	South Sumatra (Pesisir)	<i>Shorea javanica</i> , <i>Eugenia aromatica</i> , fruit trees	MICHON (1985)
Damar-mata-kucing gardens	South Sumatra (Krui)	<i>Shorea</i> spp., <i>Myristica fragrans</i> , fruit trees	TORQUEBLAU (1984)
“Parak”	West Sumatra (Maninjau)	<i>Durio zibethinus</i> , <i>Coffea canephora</i> , <i>Cinnamomum burmanii</i> , <i>Myristica fragrans</i>	MICHON (1985)
Kebun Talun system	West Java	Mixed home gardens	WIDAGDA (1984)
Tumpangsari system	Java	Forest trees (<i>Tectona grandis</i> i.a.) and annual crops	ROSYADI (2003)
Tree gardening (“Kebuns” or “Taluns”)	Java	Wide variety of useful plants, many perennial multi-purpose plants in different layers	WIERSUM (1982)
Durian/mixed fruit forest gardens	West Kalimantan	<i>Durio zibethinus</i> , and other fruit trees	SALAFSKY (1993)
Forest gardens (Tembawang)	West Kalimantan	<i>Durio zibethinus</i> , <i>Coffea canephora</i> , <i>Hevea brasiliensis</i> , <i>Arenga pinnata</i> fruit trees	SALAFSKY (1994)
Dayak garden systems	West Kalimantan	<i>Hevea brasiliensis</i> , rattans, (fruit) trees, bamboos	SUNDAWATI (1993)
Rattan gardens of the Dayak-Benuaq	East Kalimantan	<i>Calamus</i> spp., <i>Durio zibethinus</i> , <i>Nephelium</i> spp., <i>Hevea brasiliensis</i>	KRAIENHORST (1990)
Lembo culture	East Kalimantan	<i>Shorea</i> spp., fruit trees, rattans, bamboos	SARDJONO (1990)
“Simpukng” forest gardens	East Kalimantan	Rattans, <i>Hevea brasiliensis</i> , <i>Vitex pinnata</i> , fruit trees	GÖNNER (2002)
Rattan gardens	Central Kalimantan	Up to 14 rattan species, <i>Hevea brasiliensis</i> , <i>Artocarpus</i> spp., <i>Eugenia</i> sp., <i>Myristica</i> sp.	ARIFIN (2003)
Lontar palm gardens	Savu	<i>Borassus sundaicus</i>	SUNDAWATI (2001)
Kemiri gardens	Alor	<i>Aleurites moluccana</i>	WEIDELT (2001)
Sago palm gardens	Moluccas	<i>Metroxylon sagu</i>	WEIDELT (2001)

Table 1 (continued)

Name of system	Location	Dominant tree species	Described by (year)
Dusun agroforestry system	Central Moluccas	<i>Eugenia aromatica</i> , <i>Myristica fragrans</i> , <i>Cocos nucifera</i> , <i>Metroxylon sagu</i> , fruit trees	KAYA (1999)
Tree gardens and mixed gardens	Central Moluccas		STUBENVOLL (2001)
Enriched fallow	SE Sulawesi	<i>Aleurites moluccana</i> , <i>Anacardium occidentale</i>	KARIMUNA (2000)

From this literature review, it can be stated that, even though forest gardens are multi-species land use systems, each type of forest garden has one or a few (economically) dominant species. Forest gardens in Central Sulawesi are, however, not yet scientifically documented.

The term “tumpangsari” in the narrow sense is used for a particular land use system (cf. Table 1). In Indonesia, however, the term is generally used in a broader sense for different types of agroforestry systems. “Tumpangsari” is composed of the Indonesian words “tumpang” (increase) or “tumpang” (addition) and “sari” (main component, essential part) and refers to the fact that additional crops are produced besides the main crop. In Bahasa Kulawi (Kulawinese language), “tumpangtindi” is used for tumpangsari systems.

1.2.2 Ecophysiological investigations in forest gardens

Most studies about forest gardens focus on floristic, silvicultural or sociological aspects. Ecophysiological investigations, such as the measuring of PAR (Photosynthetic Active Radiation), which give information about the site conditions, have already been carried out in various land use systems. MUUB (1997) measured PAR in enrichment plantings in peat swamp forests in Sumatra, GÜNTER (2001) in natural forests in Bolivia and

PRABHU (1994) in moist tropical forests on the Andaman Islands, but no such measurements are documented for forest gardens as yet.

1.3 Objectives

Three typical forest gardens of the research area as well as neighbouring natural forests were examined. The respective forest gardens were compared to each other and to the neighbouring natural forest with regard to species composition, stand structure, stand dynamics and light regime. The following questions prevailed:

- ☞ Which plant species are used by the owner and how are they used?
- ☞ How are the forest gardens managed and which criteria are used for adaptation of the cultivated plants to the heterogeneous horizontal and vertical stand structure?
- ☞ Which site or use gradients exist within a forest garden from the settlement towards the natural forest?
- ☞ In which way do forest gardens differ from the neighbouring natural forest?
- ☞ How do the three forest gardens differ with respect to their specific environmental conditions?
- ☞ Which forest garden qualities, cultivated plant characteristics and site conditions affect the stability of the forest edges formed by forest gardens?
- ☞ Are forest gardens really sustainable land use systems?

The following objectives were formulated:

- ☞ Analysis of the local traditional knowledge about forest gardens and neighbouring natural forest, in particular cultivation and management of useful plants, their site requirements and preferences as well as their phenology and productivity (exploratory interviews),
- ☞ Recording of species composition, stand structure and phenology of useful plants and of forest-species in forest gardens and neighbouring forests,
- ☞ Definition of relevant site factors (climate, soil, light) to identify possible micro-site preferences of the useful plant species