



III. STUDY AREA AND STUDY SITES

Introduction

Towering rainforests, rugged scenery, fresh mountain streams and turbulent rivers, hot springs, unique wildlife, lichen-smothered megaliths, and a rich variety of cultures make LLNP an alluring place for modern-day tourists and scientists. Its importance becomes even more apparent when it is viewed in a geographical and geological context.

LLNP is one of Sulawesi's most important biological refuges. It contains large areas of relatively untouched terrain and varied habitats, which include lowland and upper montane forests, elfin woodland, fertile valleys, rivers, lakes, and hot springs.

Officially declared a national park on October 5, 1993, its formation amalgamated existing reserves: the Lore Kalamanta Nature Reserve, which was set aside for the protection of Sulawesi's unique endemic fauna; the Lake Lindu Recreation and Protection Forest, established to protect the catchments area of the Pelu Valley's Gumbasa River irrigation scheme, and to develop tourism; and Lore Lindu Wildlife Reserve. The new park covers an area 217,991 ha. In 1978 it was also declared a Man and Biosphere Reserve by UNESCO. It is globally recognized as a Centre for Plant Diversity and as an Endemic Bird Area by groups such as the IUCN, WWF and Birdlife International.

Lore Lindu has a tropical climate with high humidity. Temperatures vary only a few degrees over the course of the year. Daytime temperatures in lowland area of the park range from 26-32°C. Highland areas are significantly cooler, as air temperature drops 6°C (11°F) with every 1,100 m rise in height. Rainfalls throughout the year, the heaviest period occurring during the northern monsoon which lasts from November to April. There is no pronounced wet and dry season.

Altitude ranges from 200 m asl at Pakuli on the Gumbasa River, to 2,355 m asl at the summit of Mount Nokilalaki, in the northeast of the park. This range of altitudes is a contributory factor to the high level of biodiversity that is found throughout the park, as assorted plants and animals are able to inhabit the different ecological niches that this rugged landscape creates. The average annual rainfall of the park varies between 2,000 and 4,000 mm depending on location; it is generally heavier in the southern region of the park.

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Climate

Based on the comprehensive data collected by Automatic Weather Station which was installed since 2001 at Toro village by Gravenhorst et al. (2005) that the averages of relative humidity in Toro village is 85.17%, whereas ANZDEC (1997) reported that RH values are generally in the range 77 to 85% around the Lore Lindu National Park with substantially lower values, 70 to 75% in Palu Valley. While, local wind regimes are more complex, due to the undulating mountainous terrain. At a local level, variable tree height, and the surface roughness of the forest canopy can be expected to disrupt movement of the air. The average of wind speed at the study sites is 0.396 m s^{-1} .

Any variation in temperature in areas so close to the equator, are largely a result of cloud cover and altitude. The maximum daily temperature in Palu, near sea level is 32-33°C. Higher elevation are, as to be expected, significantly cooler – ambient air temperature dropping around 0.5°C for every 100 m rise in altitude. At Toro village where research took place the monthly mean temperature is 23.4°C, whereas the average annual global radiation is 17.57 MJ M^{-2} (Gravenhorst et al. 2005).

ANZDEC (1997) reported that the majority of area in the Park experiences their greatest rainfall in the months of April, May, June, and July, prior to, and at the start of, the South Monsoon. But several places around the park receive highest rainfall around April and May. The average monthly climate in Toro village from 2002 to 2004 was shown in Figure 3.1 (Gravenhorst et al. 2005).

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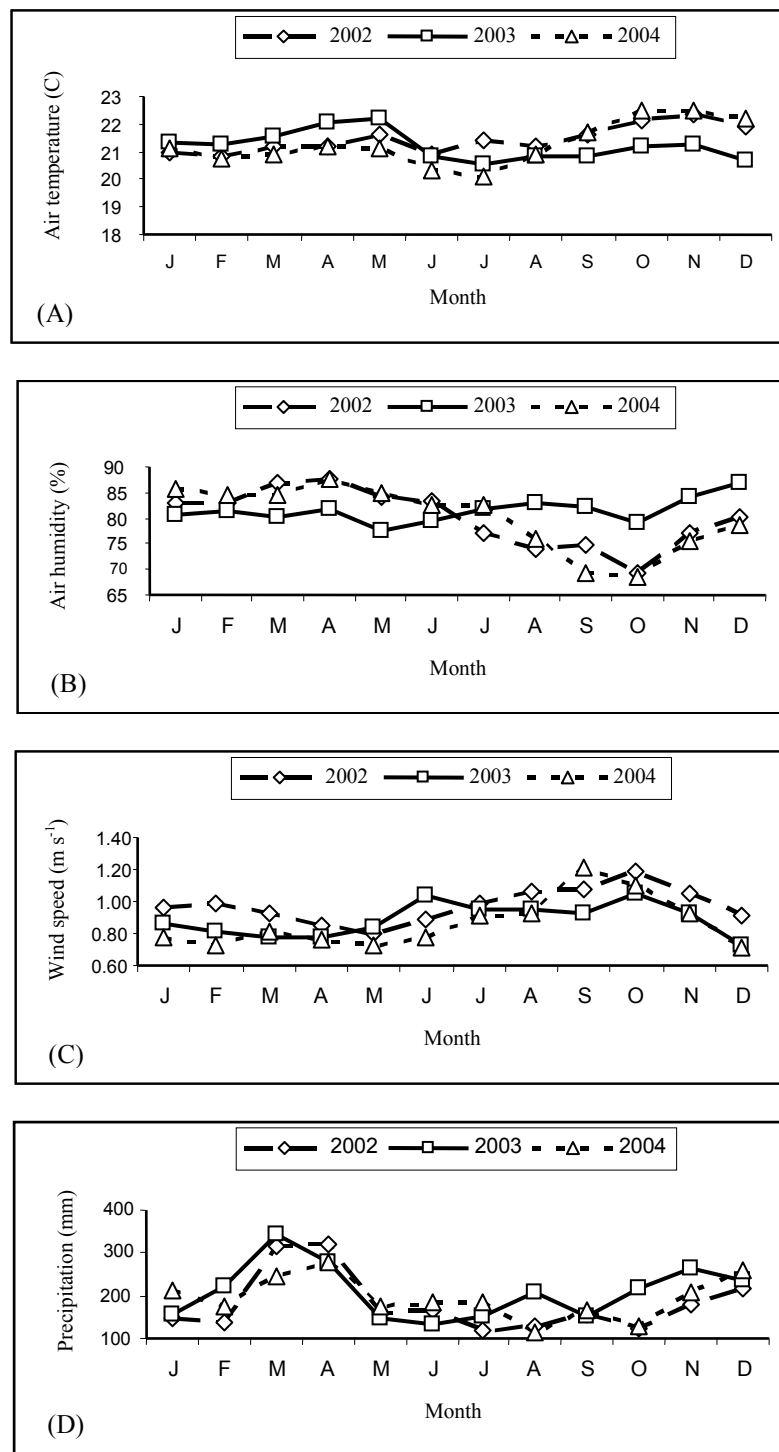


Figure 3.1. The average monthly climate in the Toro village from 2002 to 2004: (A) Air temperature, (B) Air humidity, (C) Wind speed, (D) Precipitation, and (E) Global radiation (Gravenhorst et al. 2005).

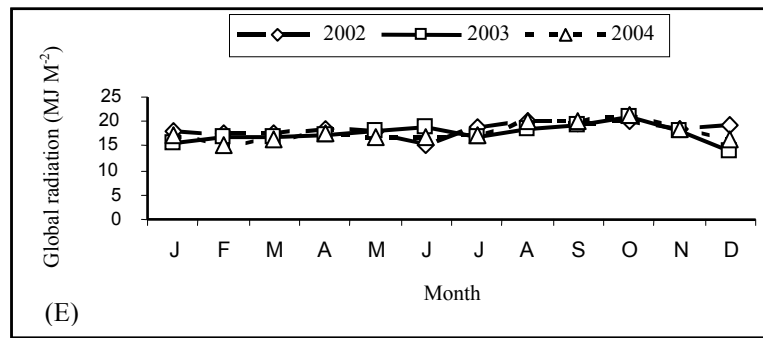


Figure 3.1. (Continued). The average monthly climate in the Toro village: (A) Air temperature, (B) Air humidity, (C) Wind speed, (D) Precipitation, and (E) Global radiation (Gravenhorst et al. 2005).

Study sites

The study area is located in Central Sulawesi, Indonesia ca. 75 km southeast of Palu at the northeastern margin of LLNP (Figure 3.2). The study was conducted at a buffer zone at LLNP, Central Sulawesi, Indonesia. The Toro village is characterized in many parts by a mosaic of primary forest, primary less disturbed forest, primary more disturbed forest, secondary forest, and several land use systems with cacao, coffee, maize, and paddy (rice) as the dominating crops (Gerold et al. 2004). Field sites covering in natural forest and in three cacao agroforestry systems were selected in Toro village, Kulawi district, Central Sulawesi, Indonesia. The whole site is located between 120°1' - 120°3'30"E and 1°29'30" - 1°32'S and the elevation of from 800 m to 1100 m. The average of relative humidity at Toro village is 87.21%, the mean of monthly temperature is 22.88°C, the average annual global radiation is 17.48 MJ/M², and the annual precipitation in 2005 recorded in the study sites was 2056 mm.

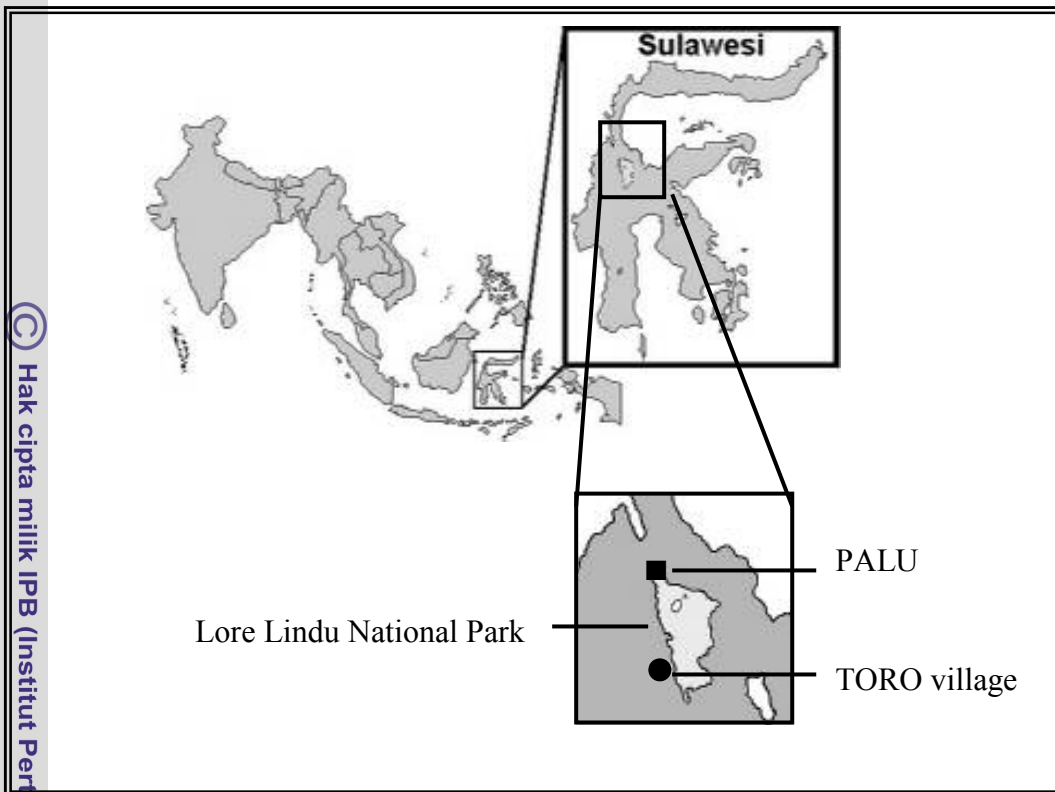


Figure 3.2. Map of study area, Toro village at the northeastern margin of Lore Lindu National Park, Central Sulawesi, Indonesia.

Actually, study sites was carried out in six land use types including three types of rain forest and three agroforestry systems namely: undisturbed natural forest (*wana*), lightly disturbed natural forest (*pahawa 1*), moderately disturbed natural forest (*pangale 2*), cacao forest garden (*pahawa pongko 1*), cacao cultivated under mixed canopy cover (*pahawa pongko 2*), and cacao cultivated under monospecific canopy tree (*huma*). The detailed of each land use types as follows:

Land use rainforest consist of:

Land use type A (*wana*): low use intensity of forest/undisturbed rainforest. Natural forest with traditional use only, human activities restricted to collecting of medicinal plants and extensive hunting; rattan palms abundantly present.

Land use type B (*pangale 1*): medium use intensity of forest. Lightly disturbed rainforest. Natural forest with rattan extraction, rattan palms removed.

Land use type C (*pangale 2*): moderate use intensity of forest /moderately disturbed rainforest. Selectively logged forest, containing small to medium sized gaps, disturbance of ground vegetation, and increased abundance of lianas following the selective removal of canopy trees and rattan.

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1. Land use cacao agroforestry systems consist of:
 - Land use type D (*pahawa pongko 1*): cacao forest garden. Cacao cultivated under natural shade trees (remaining forest cover) in the forest margin.
 - Land use type E (*pahawa pongko 2*): cacao cultivated under mixed canopy planted shade trees at the forest margin.
 - Land use type F (*huma*): cacao cultivated under canopy of monospecific planted shade trees with shade trees more distant the forest margin.
- Four different study sites were selected at buffer zone at LLNP (Figure 3.3 and 3.4), i.e., (1) Natural forest with traditional use only (type A - NF), (2) Agroforestry system (cacao) under a remaining forest cover (type D - CF1), (3) Agroforestry system (cacao) under local shade trees (type E - CF2), (4) Agroforestry system (cacao) without forest cover but with planted shade trees (type F - CP). Profile diagram of study sites shown in the Appendix 1 – 4. The species that dominate on the NF was *Palaquium quercifolium*, *Castanopsis acuminatisima*, *Ficus trachypison*, *Lithocarpus celebicus*, and *Chionanthus laxiflorus*. The cacao agroforestry type 1 (CF1) was dominated by *Theobroma cacao*, *Coffea robusta*, *Arthocarpus vrieseanus*, *Turpinia sphaerocarpa*, and *Horsfieldia costulata*. The species that dominate on cacao agroforestry type 2 (CF2) was *T. cacao*, *Erythrina subumbrans*, *Syzigium aromaticum*, *Arenga pinnata*, and *Bischofia javanica*. The cacao agroforestry (CP) was dominated by *E. subumbran*, *T. cacao*, *Glyricidia sepium*, *Melochia umbellate*, *Piper aduncum* (Ramadhanil, 2006). Planting distance of cacao tree those in the CF1 and CF2 was unregulated, but that in the CP was regulated. Planting distance of cacao tree in the CP was 3 m x 3 m. Topography of study sites is relatively flat with the different slope. The environmental information in four study sites was shown in Table 3.1. The order of four study sites NF, CF1, CF2, and CP, based on the intensity of land use types, and they indicate the increase of land use change intensity.

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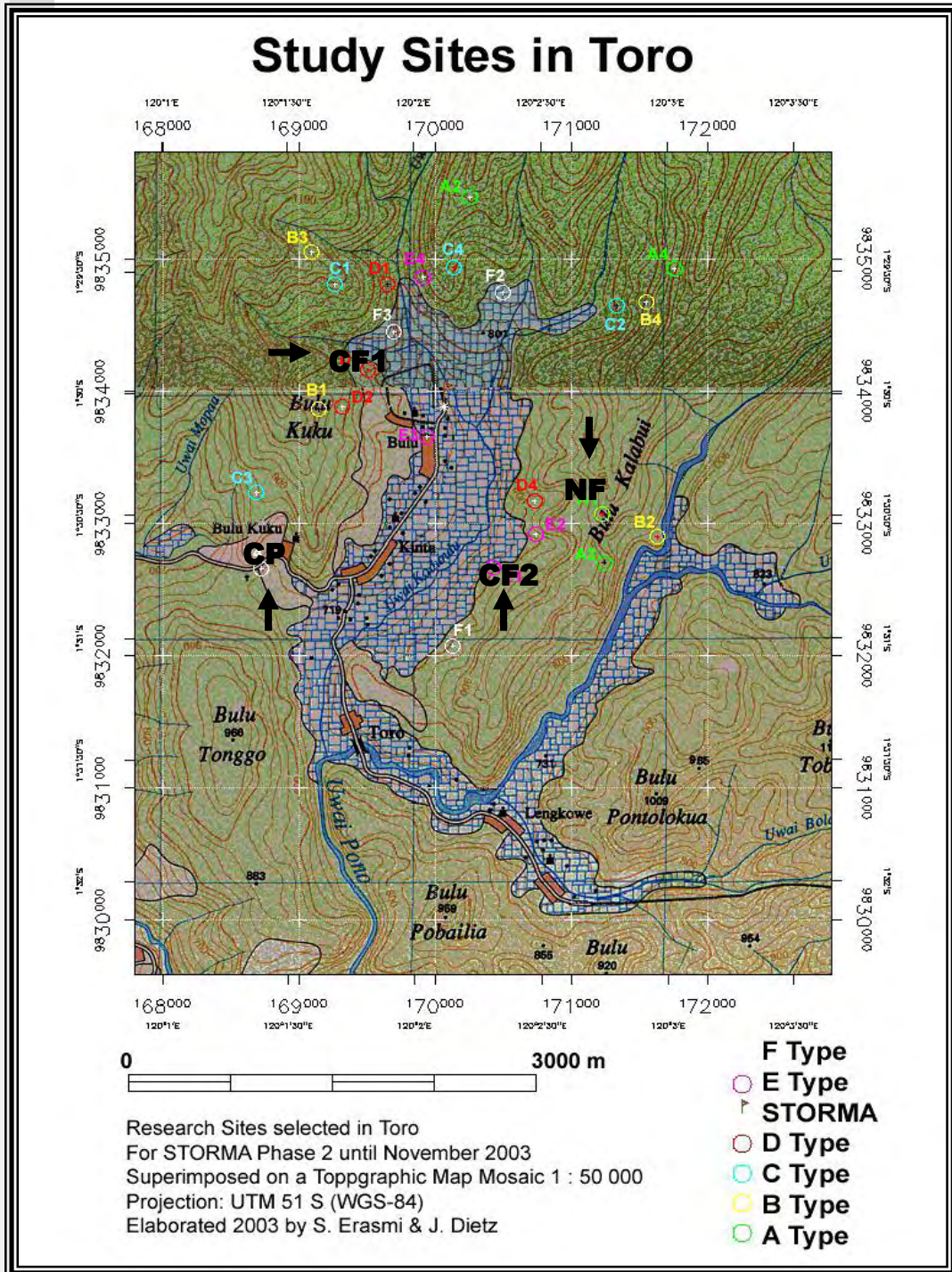


Figure 3.3. Study sites at Toro village, arrow shows study sites: NF= natural forest, CF1, CF2, and CP = cacao agroforestry systems (Erasmi et al. 2004)

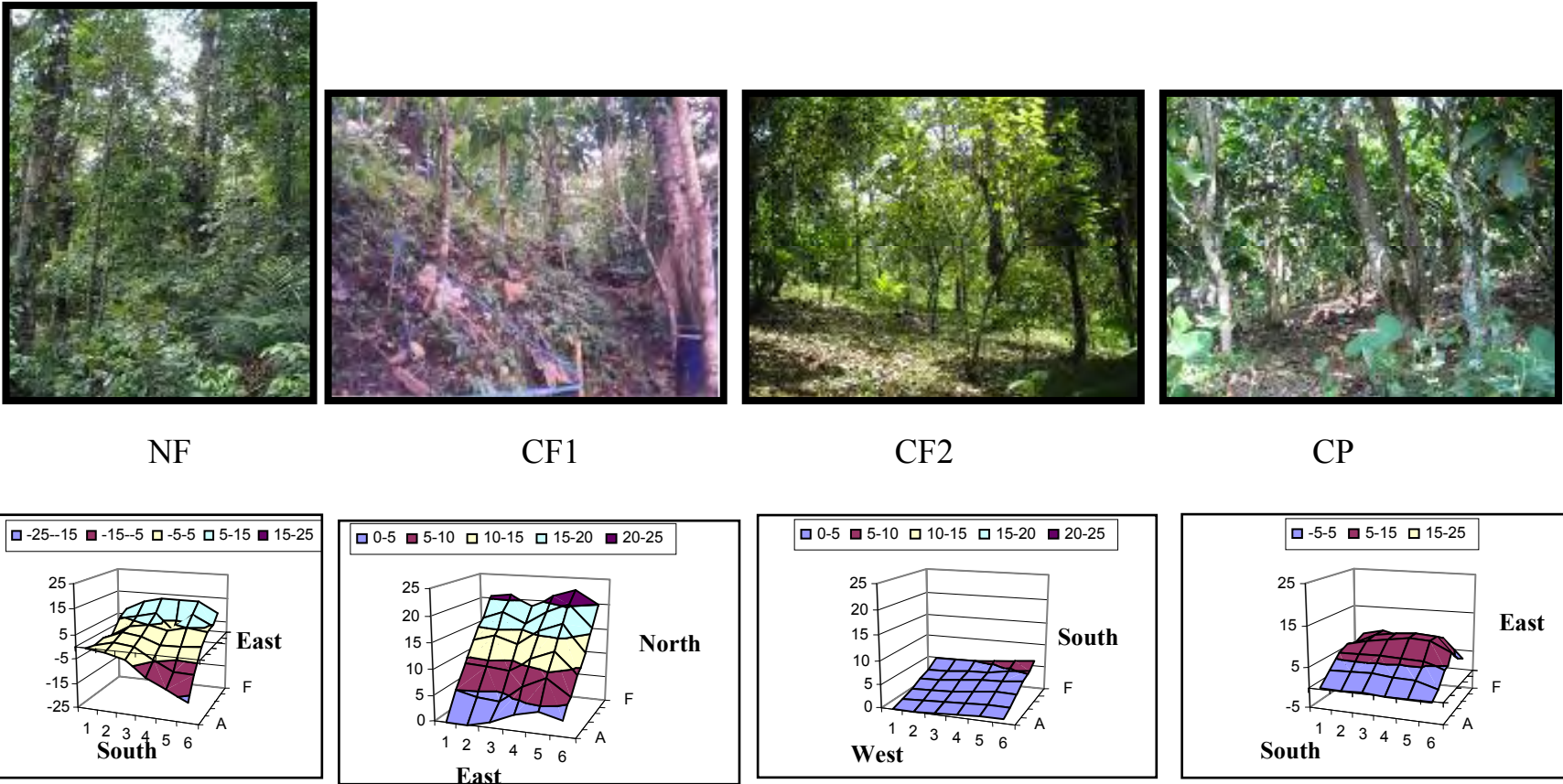


Figure 3.4. Four land use types as study sites, above: vegetation structure, below: topographic plot, NF: natural forest, CF1: cacao agroforestry system under remaining forest cover, CF2: cacao agroforestry system under local shade trees, CP: cacao agroforestry system under planted shade trees.

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Table 3.1. Environmental information in the natural forest (NF) and cacao agroforestry systems (CF1, CF2, and CP) in Toro village, Central Sulawesi.

| | NF | CF 1 | CF 2 | CP |
|---|-------|--------|--------|--------|
| Trees density (number ha ⁻¹)* | 1184 | 608 | 488 | 1208 |
| Basal area (m ²) | 58.4 | 31.5 | 6.6 | 13.2 |
| Exposition | 95° E | 110° E | 100° E | 100° E |
| Air humidity (%)** | 95.7 | 92 | 91.4 | 86.3 |
| Temperature (°C)** | 20.4 | 21.5 | 21.8 | 22.9 |
| Canopy cover (%) | 89.7 | 72.1 | 69.4 | 49.8 |
| Attitude (m asl) | 1006 | 832 | 802 | 799 |
| Slope (%) | 80 | 70 | 35 | 20 |

References:

* : Ramadhanil (2006)

** : Bos et al. (2007)

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