

Chapter I

Introduction

1.1. Motivations and objectives

Tropical forest is covering less than 7% of the terrestrial surface and has the important role in carbon cycle (Tucker *et al.* 2000) and mega-biodiversity are living inside, especially in Indonesian tropical forest (Tateishi *et al.* 2000). Figure 1.1 shows the tropical forest distribution at Indonesia (WRI 1999 and DEPHUTBUN 1997). The type of tropical forest that cover Indonesian area are lowland forest, montane forest, mangrove forest, swamp forest, and lowland monsoon forest. Kyoto protocol (UN 1997) was signed in 1997, but deforestation is being still done in many places in the world, especially at tropical forest area. Twelve million hectares of tropical forest was cleared annually (FAO 1997). Another problem is leak of tools and methods to manage and monitor the tropical forest in a large area. Indonesia is large archipelago that consists of more than 1,700 large islands with land territory covers approximately 1.9 millions square kilometres. It is very difficult to estimate age or volume of tree trunk using conventional techniques that spent much time and cost to collect its ground data.

Recently, remote sensing technology has been an efficient and helpful tool to monitor tropical forest and plantation in a large area. The main problem in monitoring tropical areas, as Indonesia, is cloudy condition. The best instrument to monitor these areas is Synthetic Aperture Radar (SAR), as it works effectively in spite of cloudy conditions. However, SAR data are not easily interpreted due to the complex relations of the radar backscattering mechanism between microwaves and tropical forest parameter (i.e. diameter of tree trunk, thickness of burnt coal seam, roughness of soil surface, soil moisture) (Kamal 1989). In this

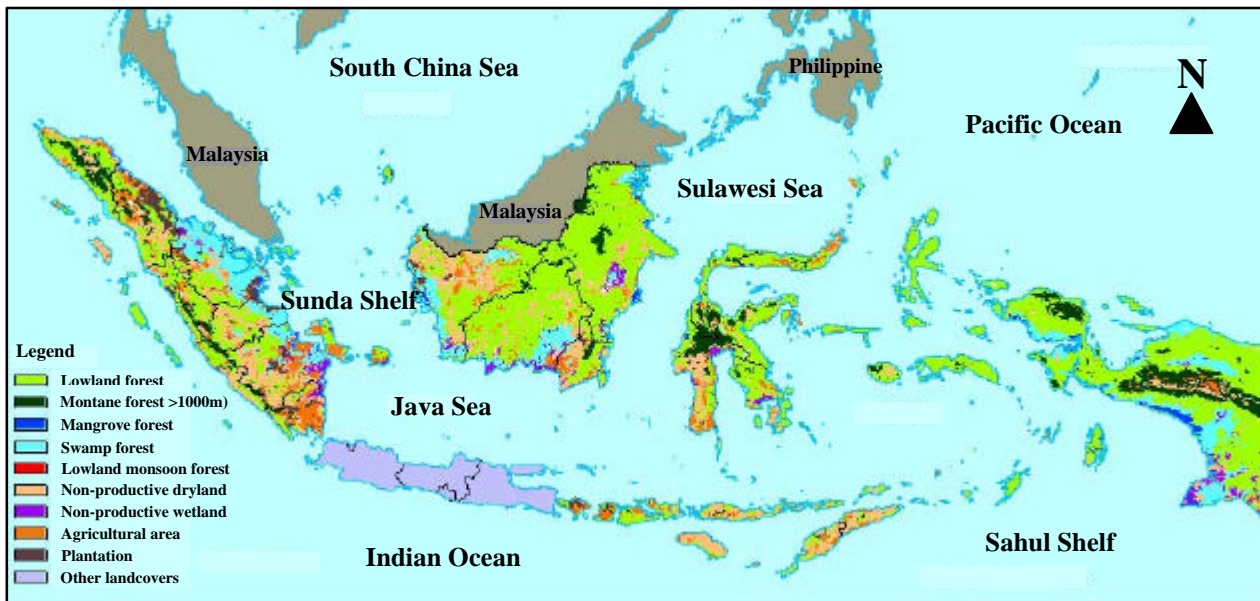


Figure 1.1. Distribution of tropical forest at Indonesia archipelago

study, the author attempts to find the relationship between the radar backscattering coefficients and its parameters that are found in tropical forest area. Figure 1.2 shows the spread of forest plantation types across Indonesia and the species planted in each province with major species are *Acacia mangium*, *Agathis spp.*, *Pinus merkusii*, *Gmelina arborea*, *Shorea spp*, *Swietenia macrophylla* etc (Nair 2000). In this research, the author also applies the proposed method to monitor these species using remote sensing techniques or SAR sensor.

1.2. Deforestation and forest fire

Deforestation in tropical regions went at a quite stable pace during 1980 – 1995, of 0.7% per year, which is about 12 million hectares annually (including reforestation) of tropical forest is lost each day. This boils down to 33,000 hectare per day. Nearly half of all species of plants and animals on earth are living in tropical forests. According to some experts something like 100 species become extinct each day, and most of them as a direct result of deforestation. Indonesia has second deforestation speed in the world, so it has high

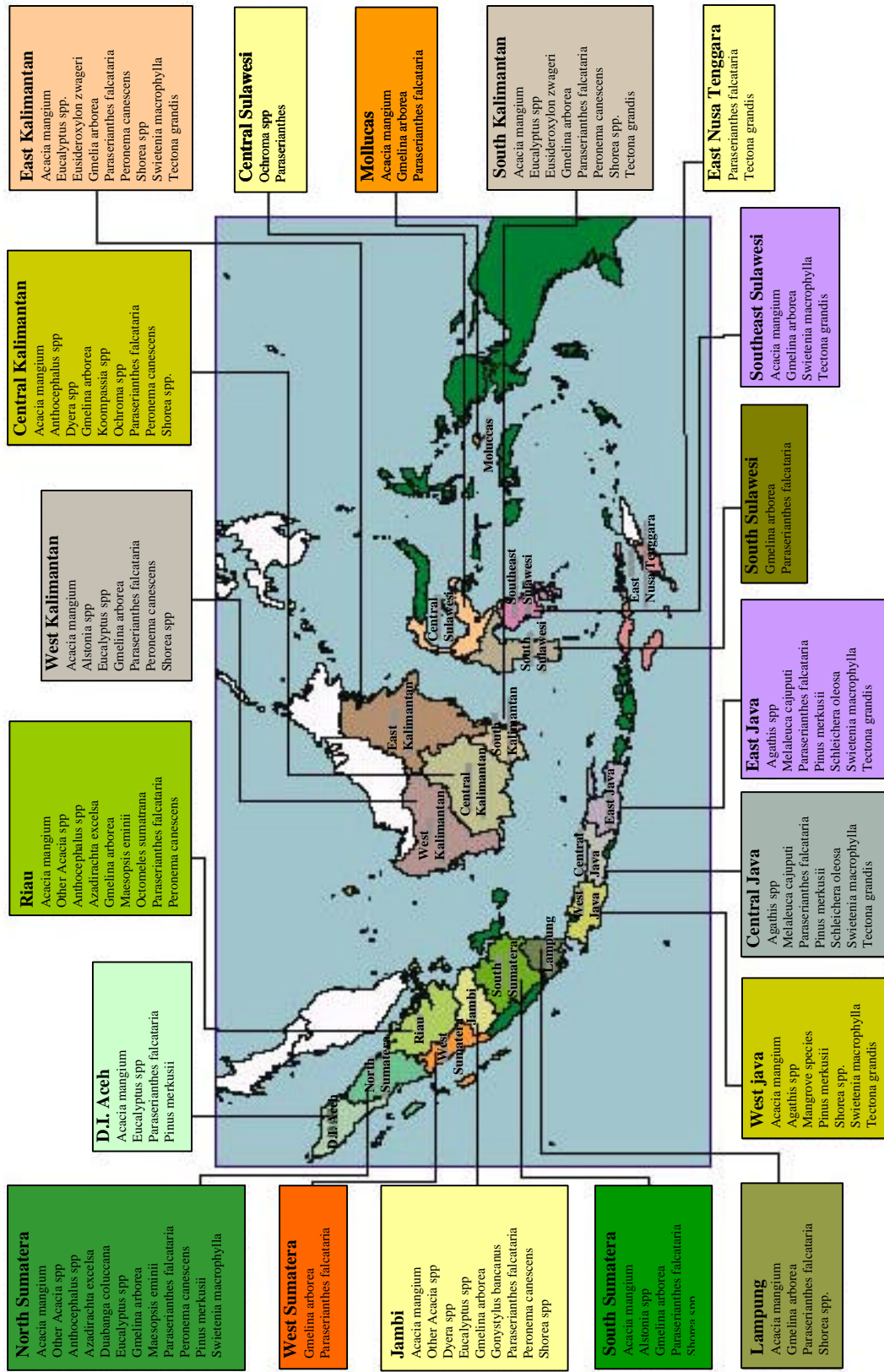


Figure 1.2. The spread of forest plantations across Indonesia and the species planted in each province

contribution in environmental destruction and indirectly influence to the carbon dioxide production over the earth (WRI 1999). In this reason, the author attempts to analyse the scattered waves from burnt coal seam to estimate the thickness of burnt coal seam. In near future, this result can be applied to estimate the carbon dioxide volume that is produced by deforestation or forest fire area, especially at Indonesian region.

The large-scale forest fire was occurred in Borneo island, Indonesia in period of 1997 to 1998 (Nakayama *et al.* 1999, Siegert *et al.* 2000, Liew *et al.* 1999). This is coinciding with the El-nino Southern Oscillation (ENSO) of 1997-1998 (Muraleedharan *et al.* 2000a). It has become air pollution episode due to the out-of-control biomass burning for agricultural purposes started in June 1997 that to be a severe environmental problem for itself and the neighbouring countries. Its impact on the health and ecology in the affected areas is expected to be substantial, costly and possibly long lasting (Fang *et al.* 1999). Figure 1.3 shows the distribution of forest fire at Borneo island, Indonesia in 1997 – 1998, where about one million hectares of forest area was devastated (Charles *et al.* 2000).

Many researchers attempted to know hotspot of forest fire and quantity of air pollution using many sensors with study sites were countries around Indonesia (Fang *et al.* 1998, Miroslav *et al.* 1999, Wolfgang *et al.* 1999). Biomass fires have been responsible for several regional haze episodes in southeast Asia, and most of the fires were in areas where peat is the dominant biomass fuel (Muraleedharan *et al.* 2000b). Muraleedharan reported that the chemical components present in the haze in southeast Asia with special emphasis on those substances with potential health impacts (Muraleedharan *et al.* 2000a). Based on these reasons, this research attempts to analyse the relationship between the thickness of burnt coal seam and radar backscattering coefficient. Then the result will be applied to estimate the thickness of burnt coal seam using Synthetic Aperture Radar (SAR) data. The study area was chosen

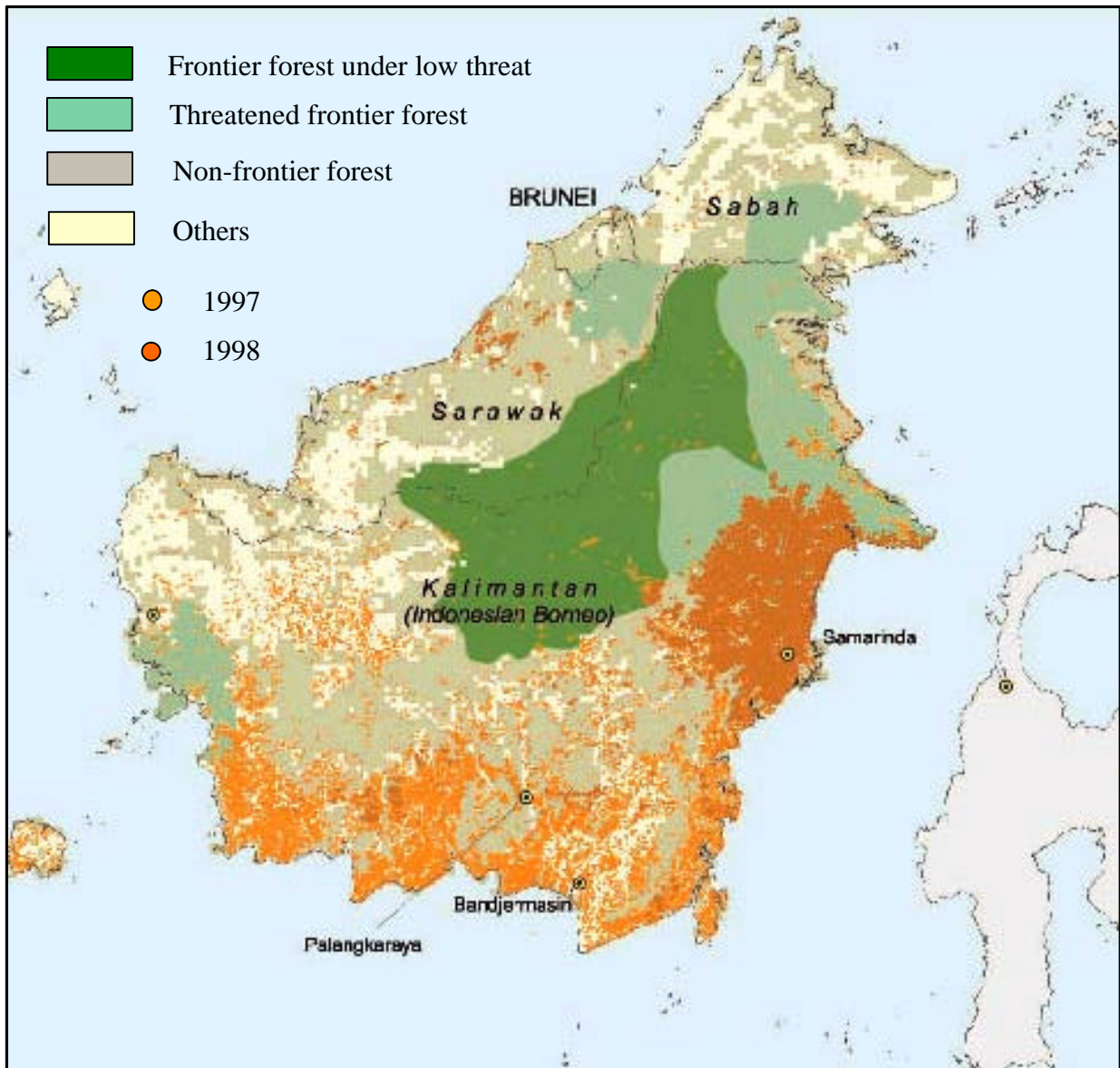


Figure 1.3. Borneo's forest cover and 1997-1998 fire hot spots

around 'One Million Hectares Peatland Project (PLG)' at central and south Borneo area. To realise this purpose, Japanese Earth Resources Satellite (JERS-1) SAR data (L band) were employed.

1.3. Japanese Earth Resources Satellite (JERS-1) Synthetic Aperture Radar

JERS-1 is a Japanese National Space Development Agency (NASDA) satellite whose mission objectives of JERS-1 are twofold; Firstly, the assessment of the newly developed onboard sensors and the spacecraft itself, and secondly, the establishment of an integrated system for observing the Earth that is focused on observations of earth resources, geology, agriculture, forestry, land use, sea ice monitoring and coastal monitoring.

The spacecraft contains two instruments: a Synthetic Aperture Radar (SAR) and an Optical Sensor (OPS), see figure 1.4. The SAR is an active microwave sensor that transmits microwave and detects the wave that is reflected back by objects (see figure 1.5 and table 1.1). It enables fine-resolution, high contrast observation and accurate determinations of topographical features. Since it is totally reliant on microwave data (1.275 GHz), it operates independent of weather conditions and cloud cover. The OPS separates the light reflected from the ground into seven spectral bands from visible to short wave infrared. It is made up of two sensors: the Visible and Near Infrared Radiometer (VNIR) and the Short Wave Infrared Radiometer (SWIR).

JERS-1 was launched on 11 February 1992 from Tanegashima Space Centre in Kagoshima, Japan on a 2 stage H-1 launch vehicle. The satellite had approximate dimensions 1.0m x 1.8m x 3.1m with payload weights approximately 1.4 tons. The spacecraft has a solar array that is approximately 8.0m x 3.4m. JERS-1 had an onboard Mission Data Recorder (MDR) that allows it to collect data even when a ground station is not in view. JERS-1 had already exceeded its 2 years design life until 11 October 1998.

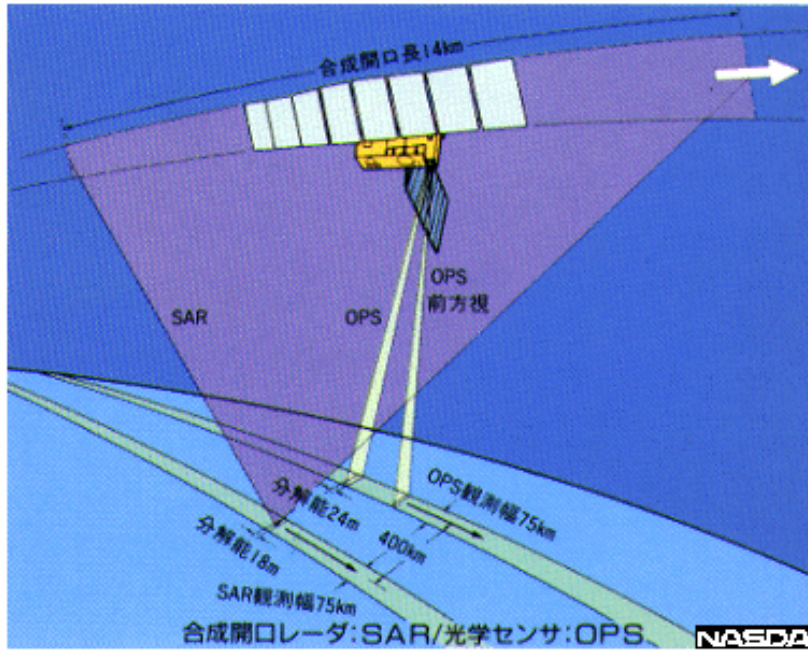


Figure 1.4. Instruments onboard on JERS-1 satellite (source: NASDA)

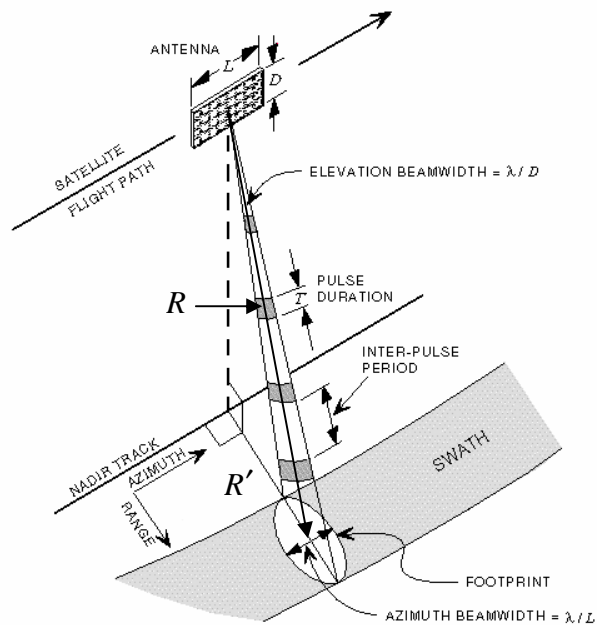


Figure 1.5. Synthetic Aperture Radar on JERS-1 satellite (source: NASDA).

Table 1.1. Specification of JERS-1 Synthetic Aperture Radar (SAR)

	Specification
Flight attitude	568km
Flight inclination angle	97.7°
Frequency	1.275GHz (L band)
Wavelength	23.5cm
Polarisation	HH
Off nadir angle	35°
Incidence angle	38.7°
Swath width	75km
Azimuth resolution	18m (3 looks)
Range resolution	18m
Peak Power	325 W (specification 1.3kW)
Band width	15MHz
Antenna size	2.2m x 12m

1.4. Physical characteristic measurements

Table 1.2 shows specification of the dielectric probe kit HP85070B (HP 2000). The dielectric constant of each sample is important parameter in modelling and analysis of the relationship between backscattering coefficient and tropical forest characteristics (i.e. tree trunk diameter, thickness of burnt coal seam, roughness of soil surface, and soil moisture). Figure 1.6 shows photographs of dielectric constant measurements that were done by the author to obtain the dielectric constant of samples, where figure 1.6 (a) and (b) shows the measurement of dielectric constant of tropical forest tree trunk media and burnt coal seam, respectively. In field survey that was done in 1999, the tree trunk samples of 17 species of tropical forest plants were collected in Indonesia. Table 1.3 shows the list of these samples. The measurement was done in frequency range from 0.3 to 3GHz. Figure 1.7 and 1.8 shows the measurement results from samples of burnt coal seam and tropical forest tree trunks, respectively. Tree trunk media were skin, xylem and heartwood. The dielectric constant of

Table 1.2. Specification of the dielectric probe kit HP85070B

	Specification
Band width	200 MHz ~ 20 GHz
Operating temperature	- 40 ~ +200°C
Probe	3.5mm connector type
Flexible cable	1m length
Terminal 50Ω	Open / Short / Load: 3.5mm connector
Probe stand	24inch, diameter 1/2inch



(a) Tree trunk



(b) Burnt coal seam

Figure 1.6. Photograph of dielectric constant measurements

each medium was measured, but the results of heartwood measurement were similar with water. Consequently, figure 1.8 shows results from the measurement of skin and xylem only.

Table 1.3. List of tropical forest species at Indonesia

No	Trade name	Botanical name	Family
1	Acacia	Acacia mangium	-
2	Coconut	Cocos mucifera	-
3	Mahagony	Swietenia mahagony	-
4	Rasamala	Altingia exelsa noronhae	Hamamelidaceae
5	Pine	Pinus Merkusii	Pinaceae
6	Rattan	Calamus	-
7	Tekik	Parasianthes lebbeck Benth.	Mimosaceae
8	Tamarind	Tamarindus indica	-
9	Teak	Tectona grandis	-
10	Orange	Citrus aurantium sinensis	-
11	Petai	Parkia Speciosa Hassk	Mimosaceae
12	Mango	Magnifera indica	Anacardiaceae
13	Mete	Anacardium occidentale	-
14	Mulwo	-	-
15	Munggur	Enterolobium saman prain	-
16	Randu (capok tree)	Cinnamomum spp.	Lauraceae
17	Sengon	Albizzia chinensis Merr.	Mimosaceae

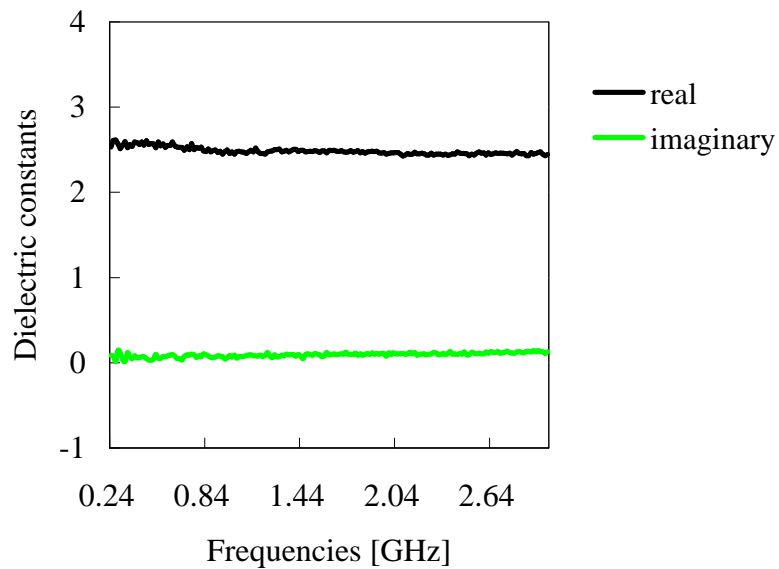


Figure 1.7. Dielectric constant of burnt coal seam

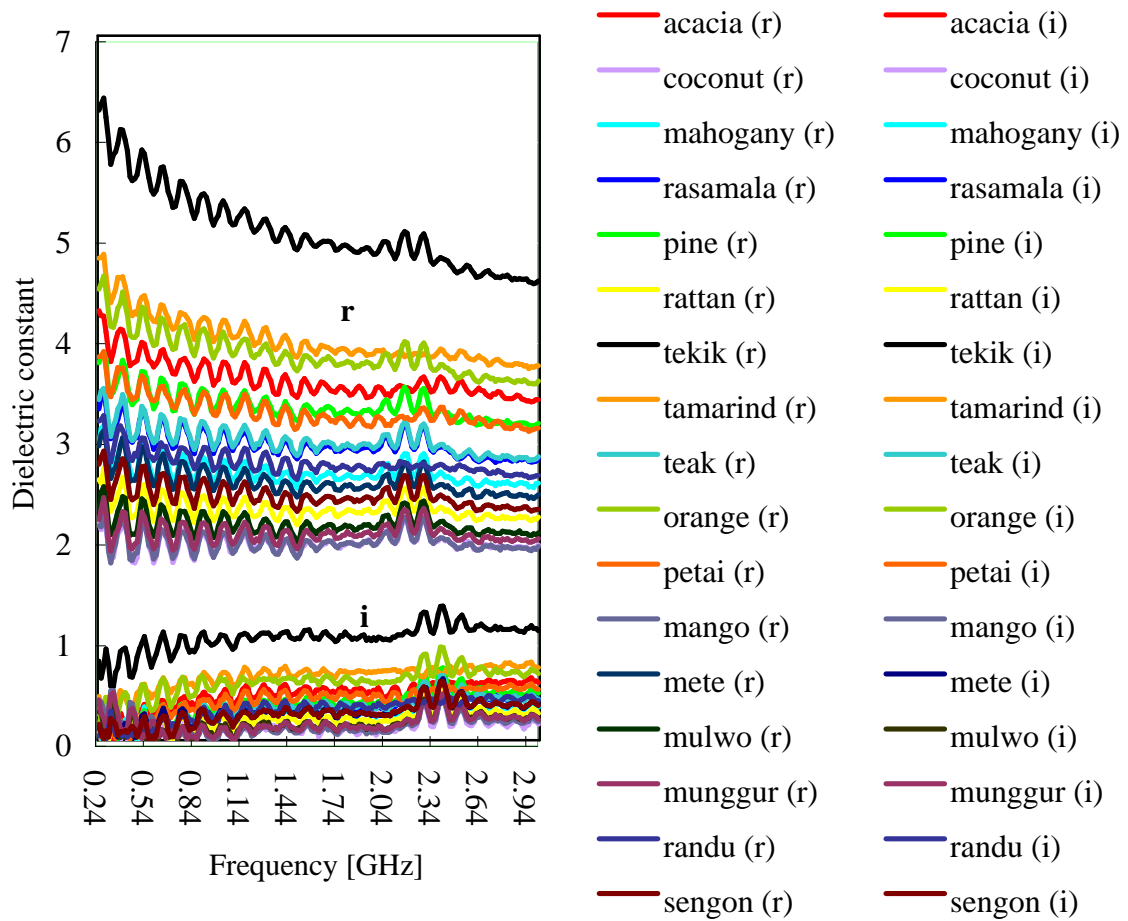


Figure 1.8 (a) Dielectric constants measurement of tropical forest tree trunk (skin): r – real part and i – imaginary part.

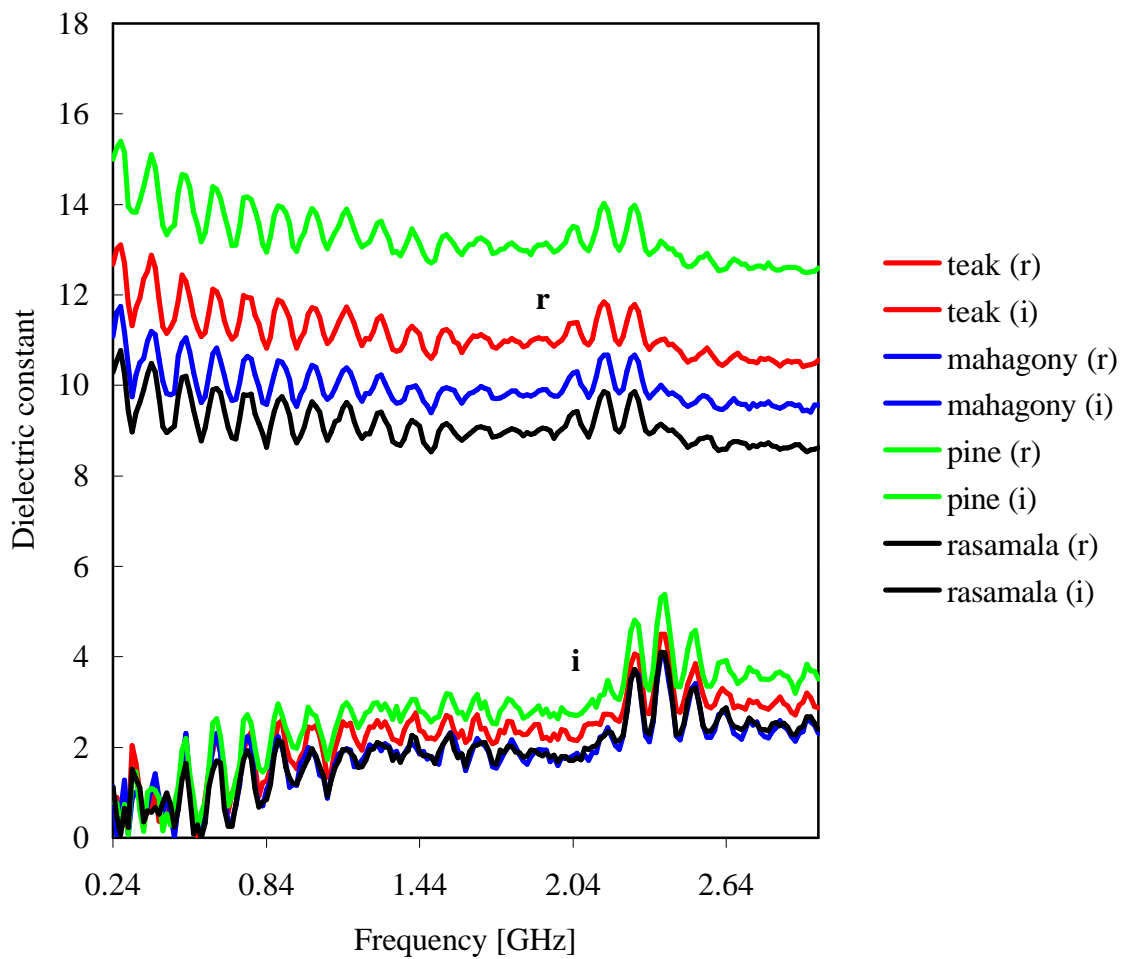


Figure 1.8 (b) Dielectric constants measurement of tropical forest tree trunk (xylem): r – real part and i – imaginary part

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