Cropping patterns and plants diversity in agroforests in Wringin village subdistrict of Wringin Bondowoso East Java

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Abstract. Agroforest has an important role to supporting food security, energy, and water sustainably. Study aimed to determine cropping patterns types and plant diversity in agroforests applied by farmers in Wringin Village Subdistrict Wringin Situbondo East Java was conducted in March 2018 used explorative and descriptive methods. Data collection was conducted by field observation and interviewing the farmers. The field observation of the type of cropping pattern was conducted by purposive sampling in agroforests. The results showed that there were several types of cropping pattern in the fields. Combination of paddy gogo (Oryza sativa L.) and cassava (Manihot esculenta Crantz) with tree plants were dominance model of cropping patterns in agroforests applied by the famers in Wringin village. The cultivated plants in agroforests have potential as fruit, vegetable, food, spice, fodder, timber and medicinal plants.

1. Introduction

The ultimate objective of land-use management at landscape level is achievement of sustainable farming systems without followed environmental degradation [1] which is characterized by high production. Agroforestry is a farming management system growing various plants which combines perennial plants (trees) with annual plants. It has been practiced by Indonesian farmers since 19th century during Dutch East Indies colonial [2] until now and the right choice and strategic to meet challenges of food scarcity, energy and water [3]. Cropping pattern has important role in agroforestry which be able to increase land productivity, environmental quality and life sustainability for the farmers [2]. The land productivity was indicated by plants products used, environmental quality and life sustainability.

Cropping pattern means proportion of area under various crops at a point of time or regional allocation of land among different crops. An ideal cropping patterns should not only overcome needs of farmers and their families for food but also to meet fodder requirement of their animals, health and wood. The choice of plants species which are cultivated in the fields depend on several factors such as soil conditions, temperature, rainfall, economic factors such as paddy gogo structure of different crops, availability of labour, capital marketing, transport facility and nearness of the market [4].

Cropping pattern of annual plants combined with parennial plants (trees) are commonly found in agroforests in Java. This will give advantages to the farmers such as (1) minimize operational cost for plants cultivation (2) increasing income per area by growing diverse plants in the same area, (3) Better
controling of pests such as insects, fungi, and weeds. Hao W. reported that intercropping maize with tomato had control effect on powdery mildew that occurs on tomato [5]. Intercropping between faba bean and wheat with sugarcane provided extra income for farmers during the early growth stage of sugarcane [6]. This system is also important to overcome the farmers for food, health, wood and other needs also increase plant diversity for food security sustainably.

Previously we reported that there were about 90 of plant species in agroforest in Gajahrejo Village, Pasuruan East Java [7]. Rahayu et al. identified 104 species of seedling of trees on rubber agroforests in Lampung [8]. There is a dominant species as a base plant in agroforest such as teak (Tectona grandis) and mahogany (Swietenia macrophylla) in Gunung Kidul [9] or other plants such as coffee (Coffea spp), cacao (Theobroma cacao), and sengon laut (Falcataria moluccana). Staple food plants commonly still to become base plants in several dryland agroforests in Java. This research aimed to know cropping patterns, plant diversity and their potential in agroforests in Wringin Village Subdistrict of Wringin Bondowoso East Java.

2. Methods

2.1. Time and location
Research was conducted in Wringin Village, Wringin District Bondowoso Regency East Java Province in March 2018 at altitude about 500 - 900 m asl. It has slopy (2–15%), steepy (15-40%) and very steepy (>40%) topography. Soil type in Wringin has been identified as regosol, grumosol and latosol soil. Regosol was the most dominant soil type in Wringin district comprised 43.37 % of the soil type (sippa.ciptakarya.pu.go.id). Wringin district is mostly dominated by dryland (tegalan) which occupied an area of 507 ha (77.68 %) from the total land use of 653 ha [10].

Dry season commonly occured between Juni–October, whereas rainy season will be occured between November–May. Average temperature was 27–30 °C with average daily temperature 25.7°C. Rainfall in 2014 recorded 1482 mm/year [10] and 2404 mm/year in 2016 [11] with air humidity 62%-69%.

![Figure 1](image.png)

**Figure 1.** Map of location : 1A= Bondowoso regency; 1B= District of Wringin; = Wringin village, district of Wringin, Bondowoso Regency, East Java [10].

2.2. Methods
Research was conducted by explorative and descriptive methods. Observation was carried in two location i.e. Dusun Palinggihan and Balongan at altitude of 500-700 m above sea level (asl) and 800-
900 asl respectively. Exploration was conducted to determine types of cropping pattern and plants diversity in the agroforests. Inventory of the cropping patterns was conducted by recording their relative frequency and plants diversity which were found along tracks in the fields during exploration. The plants diversity in this research was limited on cultivated plants or spontaneous plants which were used by farmers as food, vegetable, timber, fodder and medicinal plants. Plots of 10x10 m (for trees) and 5x5 m (for sapling) were made in each cropping pattern to analyse the vegetation. The trees category has stem diameter >10 cm and sapling has diameter 5-≤10 cm DBH. Cropping patterns for vegetation analysis were selected and determined by purposive sampling method. Inventory and identification of the plant species were conducted in the sample plots, then determined their relative density (RD), relative frequency (RF), relative dominance (Do), important value index (IVI), Shannon diversity index (H'), domination index (C) and evenness index (e').

3. Results and Discussion

3.1. Type of cropping patterns

There were two cropping patterns namely monoculture and polyculture found in Wringin village. Monoculture is growing one plant species whereas multiple cropping is planting two or more plant species in a field on the same or sequential time. Monoculture is conducted to get a high yield or harvest on one species such as paddy gogo, maize or cassava. Whereas polyculture is conducted to get yields or benefit from two or more plant species in a field area. This pattern has any advantages such as decreasing pest and diseases attack, increasing soil fertility, and increasing income also decreasing loss caused by failure of a species harvest. Perennial and annual vegetation can act as “banks” for parasitoids and predators of crop pests which to be shelter before the arrival of the target pest on the Neighbouring crop [14]. Chakraborty et al. reported that polyculture of paddy gogo +maize+ cassava give the highest benefit i.e. IDR 42,382,323.53/ ha, whereas monoculture of paddy gogo only IDR 523,740.54 /ha [15].

Actually, the farmers in Wringin village did not purely cultivated the plants monoculturely. They cultivated annual plants such as paddy gogo, maize and cassava mixed by trees as borders of area so they practised agroforestry. Agroforestry has been practised by the farmers in in Wringin village with several type of cropping patterns.

Plants species cultivated in an area during a year is very important to increase the total plants production and productivity in the area. It related to management of water resources, soil fertility, climatic condition and social economy. Wulandari et al. reported in that biophysics and social economic factors were important to the farmers in Bangladesh to decide cultivated plants species and cropping pattern they choose in the field [16]. Land possession, capital availability and technical of plant cultivation are also important factors to the farmers to decide cropping patterns they apply in the field in agroforest [17].

Annual and perennial are commonly cultivated in rainy season in November – April where water availability predicted enough for plants growth. Annual plants such as paddy gogo, maize and cassava commonly were planted in early rainy season and harvested on January-March (maize/paddy gogo) (Table 1). Maize and cassava sometime also planted in transtition of rainy and drying season in February–March. Cassava commonly was planted as intercropping with paddy gogo at about 40 days after paddy gogo planted.

There were several types of cropping patterns in agroforestry system found in Wringin village such as paddy gogo +cassava + trees; paddy gogo + cassava+ maize+ trees; kunyit + trees; cassava + trees; maize + trees (Table 2). Intercropping of paddy gogo + cassava+ trees; and cassava +trees (teak) has the highest RF in Palinggihan i.e 36.36 and 36.36, respectively ; whereas paddy gogo + trees and maize + sengon laut was the highest relative frequency in Balongan i.e 22.47 and 22.47 respectively. Paddy gogo, cassava and maize were the main staple food in this village so these plants were
commonly planted by the farmers as the main crops either in Palinggihan ang Balongan. Table 2 showed that RF of these plants was high.

Table 1. Planting Schedules of crops and trees in agroforestry system in Wringin Village, Bondowoso Regency East Java.

| No | Local name | Species            | Family          | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|----|------------|--------------------|-----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1  | Angsana    | Pterocarpus indicus| Leguminosae     | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 2  | Apokat     | Persea americana   | Lauraceae       | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 3  | Aren       | Arenga pinnata     | Arecaceae       | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 4  | Lombok     | Solanum amam      | Solanaceae      | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 5  | Duren      | Durio zibethinus   | Malvaceae       | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 6  | Gmelina    | Gmelina arborea    | Verbenaceae     | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 7  | Gude       | Cajanus cajan      | Papilionaceae   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 8  | Jagung     | Zea mays           | Poaceae         | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 9  | Jahe       | Zingiber officinal| Zingiberaceae   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 10 | Jati       | Tectona grandia    | Verbenaceae     | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 11 | Jeruk bali | Citrus maxima      | Rutaceae        | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 12 | Jeruk siem | Citrus nobilis.    | Rutaceae        | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 13 | Talas      | Xantosoma nigrum   | Araceae         | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 14 | Kelapa     | Cocos nucifera     | Arecaceae       | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 15 | Kelenken    | Dimocarpus longan  | Sapindaceae     | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 16 | Kopi       | Coffea arabica     | Rubiaceae       | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 17 | Koro       | Lablab purpureus   | Leguminosae     | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 18 | Koro pedang| Phaseolus lunatus  | Leguminosae     | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 19 | Kunyit     | Curcuma longa      | Zingiberaceae   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 20 | Lamtoro    | Leucaena leucocephalla | Leguminosae | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 21 | Mahoni     | Svealenia macrophylla | Meliaceae     | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 22 | Mangga     | Mangifera indica   | Anacardiaceae   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 23 | Nangka     | Artocarpus heterophyllus | Moraceae | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 24 | Paddy      | Oryza sativa       | Poaceae         | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| No. | Plant Name     | Family       | Precipitation (BPS 2014) |
|-----|----------------|--------------|--------------------------|
| 25  | Gogo           | Carica       | 0 0 0 0 0 0 0 0 0 x x    |
| 26  | Pisang        | Mosa         | 0 0 0 0 0 0 0 0 0 x x    |
| 27  | Rumput gajah  | Pennisetum   | 0 0 0 0 0 0 0 0 0 x x    |
| 28  | Salak         | Salacca      | 0 0 0 0 0 0 0 0 0 x x    |
| 29  | Sengon laut   | Falcataaria  | 0 0 0 0 0 0 0 0 0 x x    |
| 30  | Sirsat        | Amona        | 0 0 0 0 0 0 0 0 0 x x    |
| 31  | Tebu          | Saccarum     | 0 0 0 0 0 0 0 0 0 x x    |
| 32  | Terong        | Solanum      | x x 0 0 0 0 0 0 0 x x    |
| 33  | Ubikayu       | Manihot      | x x 0 0 0 0 0 0 0 x x    |
| 34  | Wangkal       | Albizia      | 0 0 0 0 0 0 0 0 0 x x    |
| 35  | Wuni          | Antidesma    | 0 0 0 0 0 0 0 0 0 x x    |

Note: T= high S= low N= No rain

**Figure 2.** Polyculture cropping pattern: 2A. Paddy gogo + cassava + tree (teak); 2B. Paddy gogo + trees; a. Paddy gogo (*Oryza sativa*), b. Cassava (*Manihot esculenta*), c. teak (*Tectona grandis*), d. paddy gogo (*Oryza sativa*), e) sengon laut (*Falcataaria moluccana*).

Cassava was commonly cultivated by the farmers to overcome raw materials demand of cassava tuber for home industries of cassava tuber processing in Bondowoso as popular as tape city such as “tape”, “krikik”, and “suwar-suwarir”. There were two cultivar of cassava namely “kaspro” and “mentega” which have potential to cultivate and develop to fulfill cassava tuber for industries, however markets and tape industries in Bondowoso more like and choose the cultivar of “mentega” (Figure 3) because it has more glutinous and delicious taste, although the tuber yield lower than kaspro cultivar [18]. It was also proved in the fields that almost cassava areas in Wringin village planted by the farmers with mentega cultivar. BPS reported that Wringin village is one of the main producers of tape in Bondowoso with 138 home industries so it needs more cassava tubers than other villages in Wringin district [11].
Table 2. Relative frequency (RF) of cropping and agroforests pattern in Wringin village Bondowoso Regency East Java.

| No | Type of cropping /agroforest patterns | Relative Frequency (RF) |
|----|--------------------------------------|-------------------------|
|    |                                      | Palinggihan | Balongan |
| 1  | Paddy gogo+cassava+trees             | 36.36       | 0        |
| 2  | Cassava +trees                       | 36.36       | 0        |
| 3  | Paddy gogo + Cassava + Maize + sengon laut | 5.45       | 22.47    |
| 4  | Maize + trees                        | 0           | 17.98    |
| 5  | Grass + trees                        | 5.45        | 3.37     |
| 6  | Turmeric + sengon laut               | 5.45        | 0        |
| 7  | Coffea + trees                       | 3.64        | 5.62     |
| 8  | Sugarcane + trees                    | 3.64        | 0        |
| 9  | Paddy gogo + trees                   | 0           | 22.47    |
| 10 | Paddy gogo+cassava+ Cajanus cajan + trees | 1.82   | 0        |
| 11 | Sengon laut                          | 0           | 22.47    |
| 12 | Paddy gogo + teak                    | 0           | 22.47    |
| 13 | Jabon                                | 1.82        | 0        |

Figure 3. “Mentega “, the most dominant cultivar of cassava (Manihot esculenta Crantz) in Wringin Village.

Cassava was commonly planted as intercropping between paddy gogo or maize with regular spacing of 103 cm long and 81.4 cm wide with plants density between 10,823 and 13,158 plants/ha. Cassava will become monoculture pattern if the plants canopy to be overlapping each other and will be harvested at 8-12 months after planted. Cassava was not found in Balongan at altitude >700 m asl. It may be caused by plant security and too cool for the plant growth. Balongan located near forests area where many wild pigs still lived there. They will out from the forest at night and eat the plant. So, the only paddy gogo and maize as the main annual crops were still planted in the location.
Annual food plants such as maize, cassava, and paddy gogo were planted in main parts of areas where sunlight can be reach fully. They were bounded by diverse parrenial or annual plants such as trees, benana, grasses (Pennisetum purpureum), talas (Xanthosoma nigrum) and Lablab purpureus at the edge of fields. These annual food plants were as base of agroforests in Wringin village and sometime intercropped and rotated amongs other annual plants species such as Paddy gogo+Cassava ; cassava−paddy gogo; cassava−allow- maize; and maize−cassava. Sometime, gude was intercropped in paddy gogo area. Tabacco (Nicotiana tabaccum) was reported as main crop in wringin village [11]. This plant was planted in dry season to get high leaves quality. The annual plants were planted in diverse density such as Manihot esculenta planted with density of 10823 and 13158 plants/ha (Table 3). The plants density was influenced by soil fertility, famers consideration, and their cropping patterns. Maize was planted with density of 50.000 – 74.074 plants/ha with spacing 80 cm long and 40 cm wide. Allowing the fields was commonly conducted by the farmers at dry season after the annual crops harvested. This is useful to improve soil fertility and control pests and deseases.

Table 3. The Planting space and population of basic plants in cropping pattern agroforest in Wringin Village.

| No | Species                   | Local name | Average Spacing (cm) | Population (plant/ha) |
|----|---------------------------|------------|----------------------|------------------------|
|    |                           |            | Long   | Wide   | minimum | maximum  |
| 1  | Zea mays L.               | Jagung     | 80     | 40     | 50000   | 74074    |
| 2  | Manihot esculenta Crantz. | Ubikayu    | 103    | 81.4   | 10823   | 13158    |
| 3  | Coffea canephora Pierre ex A. Froehner Linden ex de Wilden | Kopi | 179.3  | 145    | 2376    | 5128     |
| 4  | Curcuma longa L.          | Kunyit     | 100    | 6.89   | 11111   | 16667    |
| 5  | Oryza sativa L.           | Paddy gogo | 20     | 10     | 150000  | 200000   |
| 6  | Pennisetum purpureum Schumach. | Rumput gajah   | 25     | 20     | 2.10^5  | 3.10^5   |

Sengon laut (Falcataria moluccana), teak (Tectona grandis) and gmelina (Gmelina arborea) were dominant tree plants in agroforests (Table 4). They were planted by the farmers because they have high economic value, easy to plant, low input cost and can be used as building materials or furniture. They are also important to soil conservation to minimize soil erosion and to strenthen edge of fields because of the topography in Wringin village commonly undulate and hilly with sloping degree of 20-60 %. This condition has high risk to soil erosion so the field should be terraced to control and to minimize soil erosion and planted by treess at the edge of fields. Planting space of the trees on this fields was depended on their size (wide and long). Table 4 showed that the trees were planted with diverse population density such as sengon laut was planted with various density between 1333 and 1778 plants/ha. It was depended on the age of the trees and cropping pattern. The plants will be planted more dense in monoculture or multiple cropping at early time of planting (1-2 years). Its population density will be decreased following the age of the trees to increase plant growth and yield.

Annual crops such as maize, cassava and paddy gogo was important plants in agroforest cropping pattern in Wringin village. It may be caused the famers need them to fulfill their main food. The crops was also very popular, easy to plant and relatively low input cost to the farmers. Thus, these cropping patterns with food plants as the base plant in agroforests were commony found dominance in the village. It indicated that these plant species still have important role to the farmers for their life in the village. Table 2 showed that intercropping (paddy gogo+cassava), cassava (monoculture) was the dominant pattern in Palinggihan with RF of 36.3636 and 36.3636 respectively; whereas maize+sengon, paddy gogo + teak, gogo; were dominant pattern in Balongan with RF of 22.47 and 22.47 respectively. Sengon laut as monoculture commonly was planted as intercropping with maize, cassava or paddy gogo before. Actually the farmers in Palinggihan used intercropping in their field to
optimize and increase plant productivity in land use, so cassava as monoculture pattern, actually planted as intercropping with paddy gogo or maize before. This plant was sometime planted as relay planting before the paddy gogo and maize were harvested.

**Table 4.** Plant trees and tall herbaceous composition and their IVI in several cropping patterns in Wringin village.

| Local name | IVI 1 | Local name | IVI 2 | Local name | IVI 3 | Local name | IVI 4 | Local name | IVI 5 |
|------------|------|------------|------|------------|------|------------|------|------------|------|
| Sengon     | 137.90 | Pisang   | 66.70 | Sengon   | 227.56 | Jati       | 32.11 | Nangka     | 13.07 |
| Mahoni     | 20.07  | Pepaya   | 20.63 | Durian   | 38.96  | Mangga     | 24.41 | Pisang     | 49.73 |
| Gmelina    | 82.70  | Kelapa   | 52.31 | Jamblang | 33.47  | Aren       | 32.11 | Jati       | 126.01|
| Kelapa     | 38.38  | Gmelina  | 20.75 | Gmelina  | 111.7  | Pule       | 23.09 |
| Pisang     | 20.95  | Jati     | 19.58 | Mangga   | 18.31  | Angsana    | 12.84 |
|            |        | Pepaya   | 18.64 | Wuni     | 18.31  | Wuni       | 12.653|
|            |        | Lamtoro  | 31.08 | Gmelina  | 12.653 |
|            |        | Pete     | 19.58 | Gmelina  | 12.653 |
|            |        | Durian   | 31.84 | Wangkal  | 25.882 |
|            |        | Kelengke| 18.89 |         |        |

| H'         | 0.86   | C         | 0.31   | c'       | 0.53   | e'       | 0.73   | 0.40     | 0.77   | 0.55   |

1. Mixed trees, sengon laut base; 2. Kopi base; 3. Sengon laut + kunyit; 4. Gmelina + rumput; 5. Paddy gogo + ubikayu + jati; H’ = Shannon diversity index; C = Domination index; e’ = evenness index

3.2. Tree Plants composition in agroforest

There were three tree plants species which were dominant on cropping patterns in agroforests in Wringin village i.e. gmelina (*Gmelina arborea*), teak (*Tectona grandis*), sengon laut (*Falcatariamoluccana*), with IVI of 111.72, 126.01 and 137.90, respectively (Table 4). At sapling category, sengon laut, coffeea (*Coffea canephora*), Durian (*Durio zibethinus*) were dominant sapling in the agroforests with IVI of 98.63, 219.71, 175.13, respectively (Table 3). All of these plant species have high economic and use value for the farmers both for sale or use by themselves. These indicated that the high economic tree plants are important in dryland agroforest in Wringin village. It was also reported by [19] on management of damar agroforestry in Kesugihan village Lampung also reported that the farmers more like to cultivated plants which have high economic value, have sustainably production and salable.

Benana is a tall herbaceous plants which was dominant species in agroforests. Table 5 showed that it has high IVI i.e. 66.70. Benana was planted by the farmers because it has multiple use, easy to plant and has high economic value. The leaves are used for food wrapping; the flower sometime consumed as vegetable; the fruit consumed as fruit and sole to the market. This plant species are almost found planted by the farmers in lowland (<1000 m asl) agroforest in Java.

Cropping pattern in agroforest between sengon laut and kunyit has the lowest tree species diversity index (H’=0.44). whereas agroforest of coffeea has the highest tree species diversity index (H’=1.69). This difference of plant species diversity index may be caused by type of cropping pattern and fields location to the farmers residence. The observed field location of coffeea plants was in farmers home garden near their house. This location more secure and manageable for planting more plant species needed for their life than the location far from their house. Thus, it was possible for the farmers to add
plants species diversity in the cropping pattern by planting more tree species, such as rambutan, durian, orange and coconut around the coffee fields. The high plant diversity index is also reflected by the lowest dominance index value in this cropping pattern (C=0.13) which means that it has the highest number of species and diversity index values in this cropping pattern. The coffee base agroforests were developed by Bondowoso Regency Goverment in Tlogosari, Sumber Wringin and Sempol districts [20].

The cropping pattern of sengon laut and kunyit agroforest had the highest tree species dominance index (C=0.61) which means that this cropping pattern was highly dominated by one tree species namely sengon laut (IVI = 227.56) and it had the lowest number and species diversity index (H’ = 0.44). Table 4 showed that sengon laut + kunyit pattern obtained three tree plant species, i.e. sengon laut, jamblang and durian. The domination of sengon laut in this pattern was caused by this plant being the main crop and more than 5 years old with stem circumference of 40-80 cm so that under the plants canopy was very shady and not suitable for growing other of food plant species such as paddy gogo, maize and cassava.

The presence of sengon laut was very dominant in various cropping patterns in agroforests in Wringin village. This is due to it has relatively fast growing, easy maintenance, relatively resistant to pests and diseases relatively high economic value and easy to get the seedlings so that many farmers planted both monoculture and polyculture.[21] reported that cultivating sengon laut was financially feasible with Net B/C of 4.81 and PP for 5 years 8 months of age economical business for 6 years.

3.3. Potency of plants species

3.3.1. Fruit plants. The fruit plants which were found in agroforestry as many as 14 species, 13 genera and 12 families (Table 5). Banana (Musa paradisiaca) was the most dominant fruit plant planted by the famers in agroforests both not only in the fields but also in their home gardens. It may be caused that banana has several used and has high economic value to the farmers. Benana has consumed for themselves or sole to the markets; the leaf was used as food wrapping. This plants almost found in each cropping pattern with various IVI. It was the most dominant tree in agroforest with coffee as a base plant with IVI of 66.70. It has been planted by the famers not only in the fields but also in their homegardens. Also reported that banana also widely cultivated in home gardens agroforestry in East Java such as in Gajahrejo Village Pasuruan [7].
3.3.2. Vegetable plants. Vegetable is an important source of minerals and vitamins for healthy. There were 7 species, 7 genera and 3 families of potential vegetable crops such as *Solanum melongea*, *Phaseolus lunatus* and *Lablab purpureus*. These plants were rarely planted as monoculture even cultivated extensively, especially *Phaseolus lunatus*. Gude, komak, koro buncis, lamtoro commonly planted in the border of the field. The leaf of cassava has often used as vegetable and sometimes sole to the market (Table 6).

| No | Local name | Species | Family | Use     |
|----|------------|---------|--------|---------|
| 1  | Cabe       | *Solanum annum* L. | Solanaceae | Fruit   |
| 2  | Gude       | * Cajanus cajan* (L.) Huth. | Leguminosae | Fruit   |
| 3  | Koro komak | * Lablab purpureus* (L.)Sweet | Leguminosae | Fruit   |
| 4  | Koro buncis| * Phaseolus lunatus* L. | Leguminosae | Fruit/seed |
| 5  | Lamtoro    | * Leucaena leucocephala* (Lmk.)de Wit | Leguminosae | Fruit   |
| 6  | Terong     | * Solanum melongea* L. | Solanaceae | Fruit   |
| 7  | Ubikayu    | * Manihot esculenta* Crantz. | Euphorbiaceae | Leaf   |

3.3.3 Food plants. Food plants diversity is important to food security to people in marginal land or dry land such as in several regions in Bondowoso. There 8 spesies, 7 genera and 5 families of potential food plants which were planted in agroforests in Wringin village (Table 7). The dominant plants were cultivated by the farmers were maize, paddy gogo and cassava. This indicated that these plants still important to the farmers to fulfill their main food in their life. It is common found in traditional farmers/ conventional in dryland farming where input cost to be limited.
3.3.4 Timber plants. Timber plants are important component in agroforests. There were 8 species, 8 genera and 7 families of potential timber plants in agroforests in Wringin village. They have function to soil conservation to decrease soil erosion. Economic value still important factor to the farmers to decide the trees what they planted. Sengon laut, jati, mahoni and gmelina were dominant timber trees were planted by the farmers (Table 8). They have high economic value and marketable. Nangka, kelapa, jamblang and angsana were sometimes used as timber plant for house construction.

| No  | Local name | Species                        | Family      | Use        |
|-----|------------|--------------------------------|-------------|------------|
| 1   | Angsana    | *Pterocarpus indica* Wild.     | Leguminosae | stem       |
| 2   | Gmelina    | *Gmelina arborea* Roxb.        | Verbenaceae | stem       |
| 3   | Jiwet      | *Syzygium cumini* (L.) Skeels | Myrtaceae   | stem       |
| 4   | Jati       | *Tectona grandis* L.f         | Verbenaceae | stem       |
| 5   | Kelapa     | *Cocos nucifera* L.           | Arecales    | stem       |
| 6   | Paddy gogo | *Oryza sativa* L.             | Poaceae     | seed       |
| 7   | Ubikayu    | *Manihot esculenta* Crantz.   | Euphorbiaceae | stem       |
| 8   | Uwi        | *Dioscoea alata* L.           | Dioscoreaceae | stem      |

3.3.5 Medicinal plants. There were about 19 species, 19 genera, 14 family of medicinal plants such as kunyit (*Curcuma longa*), jahe (*Zingiber officinale*) and pule (*Alstonia scholaris*) (Table 9). The most medicinal plants widely planted by the farmers was Zingiber family such as kunyit (*Curcuma longa*) and Ginger (*Zingiber officinale*) which have economic value. There were 10 species of medicinal plants found in agroforest consisted of spontaneous plants (4 species) such as *Arenga pinnata*, *Syzygium cumini*, *Alstonia scholaris*, *Leucaena leucocephalla* and 13 cultivated plants such as *Persea americana*, *Annonamuricata* and *Zingiber officinale* (Table 9).

| No  | Local name | Species                        | Family      | Use              |
|-----|------------|--------------------------------|-------------|------------------|
| 1   | Apokat     | *Persea americana* Mill.       | Lauraceae   | Leaf, Seed       |
| 2   | Aren       | *Arenga pinnata* (Wurmb.) Merr. | Arecales    | Flower juice, root |
| 3   | Jagung     | *Zea mays* L.                  | Poaceae     | Fruit, silk      |
| 4   | Jahe       | *Zingiber officinale* Roxb.    | Zingiberaceae | rhizome      |
|   | English   | Scientific Name | Family | Part   |
|---|-----------|----------------|--------|--------|
| 5 | Jati      | Tectona grandis L. | Verbenaceae | Leaf, seed |
| 6 | Jamblang  | Syzygium cumini (L.) Skeels | Myrtaceae | Bark, seed |
| 7 | Kunyit    | Curcuma longa Sensu Val. | Zingiberaceae | Rhizome |
| 8 | Lamtoro   | Leucaena leucocephala (Lmk) De Wit | Leguminosae | seed |
| 9 | Laos      | Alpinia galanga (L.) Swartz. | Zingiberaceae | Rhizome |
| 10| Lombok    | Solanum annum L. | Solanaceae | fruit |
| 11| Mahoni    | Swietenia macrophylla King | Meliaceae | seed |
| 12| Nangka    | Artocarpus heterophyllus Lmk. | Moraceae | Leaf, root |
| 13| Paddy gogo| Oryza sativa L. | Poaceae | Stem |
| 14| Pule      | Alstonia scholaris (L.) R.Br. | Apocynaceae | Bark |
| 15| Pisang    | Musa acuminata x M. balbisiana | Musaceae | Stem |
| 16| Sirsat    | Amona muricata L. | Annonaceae | Leaf |
| 17| Tebu      | Saccharum officinarum L. | Poaceae | Stem |
| 18| Temu kunci| Boesenbergia rotunda (L.) Mansf. | Zingiberaceae | Rhizome |
| 19| Ubikayu   | Manihot esculenta Crantz | Euphorbiaceae | Leaf |

3.3.6. Other potential of cultivated plants. There were several plants which have other use as animal fodder such as grasses (Pennisetum purpureum, Zea mays, Oryza sativa, Saccharum officinarum), angsana (Pterocarpus indicus) and lamtoro (Leucaena leucocephala). Stem juice of Tebu (Saccharum officinarum) and flower juice of Arenga pinnata have been used as raw material of sugar. Arenga pinnata grew spontaneous and has not been cultivated by the farmers. It commonly is dispersed and distributed to any location by animals such as rat.

*Pennisetum purpureum* is one of important grasses which has been cultivated and has economic value as animal fodder. This grass is one of important grass as fodder animal in Wringin. It has been cultivated broadly in east Java monoculturally or polyculture such as in agroforest. In Wringin village this grass commonly was planted at the edge of field.

4. Conclusion

Cropping pattern of paddy gogo and cassava combined by trees was dominant cropping patterns in agroforests in Wringin village Wringin district Bondowoso East Java. Coffea base agroforestry had the highest tree plant diversity index whereas kunyit + sengon laut agroforestry had the lowest tree plant in Wringin village.

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