Tree species preference and rehabilitation perspective by local community: Case study in Bondowoso, East Java, Indonesia

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Abstract. Danarto SA, Budiharta S, Fauziah. 2019. Tree species preference and rehabilitation perspective by local community: Case study in Bondowoso, East Java, Indonesia. Asian J For 3: 54-63. Study of community’s preference on tree species used for rehabilitation programs was conducted in Gubrih sub-watershed, Sampean watershed in Bondowoso District, East Java. The aim of the study was to find out tree species that have ecological values as well as are preferred by local community for rehabilitation program in the region. Questionnaires were distributed to respondents chosen randomly (i.e. to minimize bias) to select tree species which have ecological and/or economic values. Result of the study showed that among 62 species of trees listed in the questionnaire, there were 45 species chosen by the respondents. There were 13 species of trees selected by more than 20% of total of respondent (high preferred), suggesting the potential list of species for rehabilitation programs in the region. Local community in Gubrih Sub-watershed have understood the importance of trees as a source of income as well as a measure to conserve environmental functions. This is strengthened with land-use systems they selected which prefer tree-based land-use system, such as in the form of plantation of timber species and agroforestry over dry land agriculture. The findings of this study suggest that there is opportunity in rehabilitating degraded lands in Sampean watershed using tree species preferred by local community under the land use system of timber plantation or agroforestry. Our study demonstrates that similar strategy of incorporating ecological and socio-economic perspectives could be applied to another regional context to enhance the chance of success of rehabilitation programs.

Keyword: Land degradation, land rehabilitation, trees preferences, social-ecological systems, watershed

INTRODUCTION

Deforestation and land degradation in Indonesia, especially in Java, had been occurred long time ago caused by forest clearing for agricultural activities to feed the expanding population and for developing settlements. The exploitation of forest has then been accelerated in the Dutch and Japanese colonial periods and have been continuing until now, resulting in the decreasing extent of forested areas (Nawir et al. 2007). Land conversion and exploitation from forested or tree-based vegetation into different land uses, such as agriculture, urban settlement, and industries, have sometimes been lacking to consider soil conservation practices, causing soil degradation (Faisol and Indarto 2010). Soil degradation in the form of erosion can lead to further environmental deterioration through sedimentation, pollution and increased flooding (Morgan 2009). These conditions have been the driving force behind rehabilitation programs since the colonial eras with the main objective were to conserve soil and water.

Land rehabilitation is necessary to improve biological and habitat diversity at a landscape level, increase the productivity of land by planting trees to generate timber and non-timber products, enhance forest functions such as water storage, water balance, sequestration of carbon, climate mitigation, and restore soil fertility and physical properties for protection against erosion (Kobayashi et al. 2001). In other perspectives, land rehabilitation by tree planting can promote human well being (i.e. economic benefits and quality of life) as described by Fisher et al. (1996). The economic benefits of rehabilitation can be in the form of additional incomes from selling timber and non-timber products, while the quality of life includes reduced heat effect, pollution reduction, fresh air and aesthetic view as the results of planting trees (Elmqvist et al. 2015; Roy et al. 2012).

Forest and land rehabilitation conducted either at a site level (i.e. small area consisting single land management) or at a landscape scale (i.e. large area consisting multiple land management) will affect different people in different ways. As such, people perception toward forest and land rehabilitation programs influence the success or failure of such programs. There were many cases of rehabilitation programs failed because of the lack of involvement of local communities or ignorance of their interests when implementing the programs (Lamb and Gilmour 2003). Perception, acceptance, and participation by local communities in forest and land rehabilitation are important when designing forest rehabilitation programs to enhance feasibility and likelihood of success of the programs (Kobayashi 2004; Budiharta et al. 2016). Study by Soejo and Budiharta (2013) showed that there are some tree species selected by local people for rehabilitation of open area around water spring in Pasuruan East Java with the purposes of delivering ecological functions and providing socio-economic benefits. Study of trees preferences...
conducted by Salam et al. (2000) demonstrated that there are many factors influencing trees preference by farmers in agroforestry system in which the farmers preferred economic benefits rather than ecological concerns.

The selection of tree species for land rehabilitation needs several aspects to consider, including socio-economic aspects, socio-cultural values, environmental services, general performance of tree species, and aspects of biodiversity whether the species are native or exotic/alien species (Reubens et al. 2011). While there are several studies on social and ecological aspects on forest and land rehabilitation, there is little information of community’s preference on species selection and land uses management at watershed level. Several previous studies discussed the role communities in selecting trees for land rehabilitation including trees preferences for water spring rehabilitation (Soejono and Budiharta 2013), rehabilitation of degraded land in Kenya (Glover 2012), selection of tree species in the form of agroforestry for slope stability in North Korea (He et al. 2015), and selection of trees for forest reforestation in the Philippines (Chechina and Hamann 2015). This research seeks to investigate the preference of villagers in selecting tree species for land rehabilitation programs in Sampean watershed, Bondowoso District, East Java and factors that influence those selections in regard to social, economic and ecological objective of land management.

**MATERIALS AND METHODS**

**Study areas**

This study was conducted in Gubrih sub-watershed, as a part of Sampean watershed in Bondowoso, East Java on April-May 2016. Gubrih sub-watershed encompasses three sub-districts, i.e. Wringin, Tegal Ampel and Pakem. Study location has temperature ranging from 20.4 - 25.9°C with average temperature is 25.7°C. Average rainfall is 6475 mm/year with long rain time is 9 days per month. Minimum rainfall is 1622 mm in June while maximum rainfall is 13102 mm in January. Dry season occurs from June to October while the rainy season occurs from November to May. Soil type that dominates the study location is regosol (Bapeda Jawa Timur, 2013).

Forest cover in Bondowoso is 59.867.95 ha, consisting of watershed protection forest (hutan lindung) with an area of 30.863.70 ha that covers 33.99% of Sampean watershed. Other land uses are timber plantation (kebun pohon), agroforestry (kebun campur), rice field (sawah), non-rice crop field (tegalan) and settlement area, covering of 7.59%, 19.76%, 27.70%, and 4.62% respectively (Asmaranto et al. 2012). Previous study suggested that the ideal composition of land use in Sampean watershed consists of plantation and agroforestry area with a portion 28,71% of total extent, rice field (3,12%), non-rice crop field (20,27%) and settlement (3,22%) (Asmaranto et al. 2012). The gaps between the ideal and existing conditions especially on tree-based vegetation cover (i.e. plantation/agroforestry) requires study on how to increase such land cover through land rehabilitation.

![Figure 1](image-url)  
**Figure 1.** Study location in Bondowoso District, East Java Province, Indonesia, which include Sub-districts of Pakem (1), Wringin (2), and Tegal Ampel (3)
Table 1. Species of trees to select by respondents at the studied areas in Gubrih sub-watershed, Sampean watershed, Bondowoso District, East Java, Indonesia

<table>
<thead>
<tr>
<th>Species</th>
<th>Family</th>
<th>Local name</th>
<th>Potency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albizia procera (Roxb.) Benth.</td>
<td>Fabaceae</td>
<td>Wangkal</td>
<td>Ecology and economy</td>
</tr>
<tr>
<td>Aleurites moluccanuus (L.) Willd.</td>
<td>Euphorbiaceae</td>
<td>Kemiri</td>
<td>Ecology and economy</td>
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<td>Alstonia scholaris (L.) R. Br.</td>
<td>Apocynaceae</td>
<td>Pule</td>
<td>Ecology</td>
</tr>
<tr>
<td>Anthocephalus cadamba (Roxb.) Miq.</td>
<td>Rubiaceae</td>
<td>Jabon</td>
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<td>Antidesma bunius (L.) Spreng.</td>
<td>Euphorbiaceae</td>
<td>Buni</td>
<td>Ecology</td>
</tr>
<tr>
<td>Artocarpus altillis (Parkinson ex F. A.Zorn) Fosberg</td>
<td>Moraceae</td>
<td>Sukun</td>
<td>Ecology and economy</td>
</tr>
<tr>
<td>Artocarpus heterophyllus Lam.</td>
<td>Moraceae</td>
<td>Nangka</td>
<td>Ecology and economy</td>
</tr>
<tr>
<td>Bischofia javanica Blume</td>
<td>Phyllanthaceae</td>
<td>Gintungan</td>
<td>Ecology</td>
</tr>
<tr>
<td>Buchanania arborescens (Blume) Blume</td>
<td>Anacardiaceae</td>
<td>Gerok ayam</td>
<td>Ecology</td>
</tr>
<tr>
<td>Calophyllum inophyllum L.</td>
<td>Clusiaceae</td>
<td>Nyamplung</td>
<td>Ecology</td>
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<td>Cananga odorata (Lam.) Hook.f. &amp; Thomson</td>
<td>Annonaceae</td>
<td>Kenanga</td>
<td>Ecology and economy</td>
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<tr>
<td>Canarium vulgare Leenh.</td>
<td>Burseraceae</td>
<td>Kenari</td>
<td>Ecology</td>
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<td>Trengguli</td>
<td>Ecology</td>
</tr>
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<td>Celastrus pentandra (L.) Gaertn.</td>
<td>Bombacaceae</td>
<td>Randu</td>
<td>Economy</td>
</tr>
<tr>
<td>Coffea arabica</td>
<td>Fabaceae</td>
<td>Kopi</td>
<td>Economy</td>
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<tr>
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<td>Ebenaceae</td>
<td>Bispul</td>
<td>Ecology</td>
</tr>
<tr>
<td>Draccontomelon dao (Blanco) Merr. &amp; Rolfe</td>
<td>Anacardiaceae</td>
<td>Rau</td>
<td>Ecology</td>
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<tr>
<td>Durio zibethinus L.</td>
<td>Bombacaceae</td>
<td>Duren</td>
<td>Economy</td>
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<td>Dyssoxylum gaudichaudianum (A.Juss.) Miq.</td>
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<td>Kodoyo</td>
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<td>Erythrina orientalis Murray</td>
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<td>Ficus variegata Blume</td>
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<td>Ecology</td>
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<td>Gmelina arborea Roxb.</td>
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<td>Gmelina</td>
<td>Economy</td>
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<td>Leucaena leucoephalia (Lam.) de Wit</td>
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<td>Liriope glutinosa (Lour.) C.B.Rob.</td>
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<td>Kecik-kecik</td>
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<tr>
<td>Michelia alba DC.</td>
<td>Magnoliaceae</td>
<td>Cempaka</td>
<td>Ecology</td>
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<td>Panguim edulis Reinw.</td>
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<td>Kluwek</td>
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<td>Paraserianthes falcataria (L.) I.C.Nielsen</td>
<td>Fabaceae</td>
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<td>Parkia timoriana (DC.) Merr.</td>
<td>Fabaceae</td>
<td>Kedawung</td>
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<td>Peltophorum pterocarpum (DC.) K.Heyne</td>
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<td>Saga</td>
<td>Ecology</td>
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<td>Persea americana Mill.</td>
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<td>Alpukat</td>
<td>Economy</td>
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<td>Pipturus sp.</td>
<td>Urticaceae</td>
<td>Senu</td>
<td>Ecology</td>
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<td>Matoa</td>
<td>Economy and ecology</td>
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<td>Syzygium aequale (Burm.f.) Alston</td>
<td>Myrtaceae</td>
<td>Jambu air</td>
<td>Economy</td>
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<td>Pterocarpus indicis Wildill.</td>
<td>Fabaceae</td>
<td>Angsana</td>
<td>Ecology and economy</td>
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<td>Pterocynium tintorium Merr.</td>
<td>Palongan</td>
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<td>Sapindus rarak DC.</td>
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<td>Klerek</td>
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<td>Saraca indica L.</td>
<td>Fabaceae</td>
<td>Asoka</td>
<td>Ecology</td>
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<td>Schleichera oleosa (Lour.) Merr.</td>
<td>Sapindaceae</td>
<td>Kesambi</td>
<td>Ecology</td>
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<td>Senna siamea (Lam.) H.S.Irwins &amp; Barney</td>
<td>Fabaceae</td>
<td>Johar</td>
<td>Ecology</td>
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<td>Spondias dulcis Parkinson</td>
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<td>Sterculia cordata Blume</td>
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<td>Swietenia macrophylla King</td>
<td>Meliaceae</td>
<td>Mahoni</td>
<td>Economy</td>
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<td>Syzygium cumini (L.) Skeels</td>
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<td>Buah Susu</td>
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<td>Citrus maxima (Burm.) Merr.</td>
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<td>Jeruk bali</td>
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<td>Kelengkeng</td>
<td>Economy</td>
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<td>Garcinia mangostana L.</td>
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<td>Glicricidia sepium (Jacq.) Kunth ex Walp.</td>
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<td>Gnetum gnomon L.</td>
<td>Gnetaceae</td>
<td>Melinjo</td>
<td>Economy</td>
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<td>Lansium domesticum Correa</td>
<td>Meliaceae</td>
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<td>Economy</td>
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<td>Anacardiaceae</td>
<td>Mangga</td>
<td>Economy</td>
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<td>Manilkara cao (L.) Dubard</td>
<td>Sapotaceae</td>
<td>Sawo</td>
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<td>Melia azedarach L.</td>
<td>Meliaceae</td>
<td>Mindi</td>
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<td>Rambutan</td>
<td>Economy</td>
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<td>Parkia speciosa Hassk.</td>
<td>Fabaceae</td>
<td>Petai</td>
<td>Economy</td>
</tr>
<tr>
<td>Sessania grandiflora (L.) Pers.</td>
<td>Fabaceae</td>
<td>Turi</td>
<td>Economy</td>
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</tbody>
</table>
Data collection

This study used questionnaires to collect data which were distributed randomly to respondents. Sampling method used in this survey was simple random sampling. This method allows each member of the population (villager) to have an equal chance of being selected to minimize bias (Groves et al. 2009). Survey was conducted in Gubrih Sub-watershed which encompasses three Sub-districts with total 15 villages, i.e. Wingin Sub-districts (village: Gubrih, Jambe Wungu, Wringin, Ampelan, Sumber Malang, Jatisari, Banyuwuluh, and Banyuwuluh 2), Tegal Ampel Sub-districts (village: Tanggul Angin, Klabang Agung, Karanganyar, Mandiro, Sekar Putih, Klabang), and Pakem Sub-districts (village: Pakem). Total number of villagers being interviewed was 98 with gender composition of 63 males and 35 females. Each respondent was interviewed according to the list of questions contained in the questionnaire.

The questionnaire contains closed questions about tree species to select by the respondent for rehabilitation in Sampean Sub-watershed. The list of tree species was developed by identifying species with specific criteria in term of ecological and economic perspectives. The ecological perspectives refer to tree species found at natural ecosystems nearby with similar biotic and abiotic factors, or so-called the reference site (Fiqa and Darmayanti 2017). In addition, tree species with high carbon sequestration were also considered to complement the ecological criteria (Danarto et al. 2013). Carbon sequestration is ability of plants to absorb CO2 from atmosphere and then stored as biomass (Hairiah et al. 2011). From economic perspective, tree species with economic value were considered. In the end, there were 62 species of trees to be selected by the respondents as shown in Table 1.

In addition to species preference, analysis on factors affecting community preference in selecting particular tree species for land rehabilitation was also conducted. Basic information at respondent level was collected including age, gender, education level, access of transportation to their land (i.e. easy, moderate, difficult), topography of their land (i.e. flat, sloping and steep), and primary occupation. Respondents were also asked about their perception of the importance and benefit of trees in their life, their preferred land management (i.e. timber plantation/kebun pohon, agroforestry/kebun campur, rice field/sawah, non-rice crop field/tegalan), and their acceptance for rehabilitation programs implemented on their lands.

Statistical analysis

Collected data were analyzed using Pearson Chi-square test to examine associations between two variables. In particular, we examined association between the variables of transport access versus preferred land management by the respondent, and between land topography versus preferred land management by the respondent. The equation for the Chi-square analysis is as follows:

$$X^2_p = \sum \frac{(Fij-Eij)^2}{Eij}, \text{ with } df \text{ (degree of freedom) } = (R-1)(C-1),$$

Where:

- $X^2_p$ = chi-square analysis
- $F_{ij}$ = observed value
- $E_{ij}$ = expected value
- $R$ = number of lines
- $C$ = number of columns

The level of confidence to determine significance is 95%, meaning that there is a significant association between variables if $p$ value < 0.05 (Egbue and Long 2012).

RESULTS AND DISCUSSIONS

Respondents’ composition

Education level varied among villagers with the highest proportions at the level of elementary school (Sekolah Dasar) with percentage of 48.97%, followed by no receiving education with percentage of 12.24% (Figure 2). Other educational levels such as middle level, high level, and college level have fewer percentage. Variable of age also varied among villagers. Most of respondents in this study have age of more than 40 years, while respondents with age of less than 30 years and between 30-40 years old have equal proportion (Figure 2).

Preferred species of trees for rehabilitation programs by local community

One step in rehabilitation of degraded areas is the selection of species of trees preferred by local community for rehabilitation programs to enhance community’s acceptance and participation. The results of this study showed that among 62 of tree species listed in the questionnaire, there were 45 species chosen by the local community for rehabilitation programs in Gubrih Sub-watershed (Figure 3). Most of the selected tree species have economic potentials, including the potential for wood, fruits, cooking spices and stimulants. Highly preferred tree species are sengon (Paraserianthes falcataria), durian (Durio zibethinus), gmelina (Gmelina arborea), java (Artocarpus altilis) and mangoes (Mangifera indica) in which each of them was selected by more than 20% of the respondents. Tree species such as klengkeng (Nephelium lappaceum), jeruk bali (Citrus maxima), jambu (Annona squamosa), lamtoro (Leucaena leucocephala) and kedondong (Spondias malayana) were moderately preferred as it was chosen by 6-20 % of the respondents. As many 21 species are less preferred by community with percentage of respondent ranged from 1-5% including manggis (Garcinia mangostana), buni (Antidesma bunius), matea (Pometia pinnata), sawo (Manilkara kaoui), buah susu (Chrysophyllum cainito), duku (Lansium domesticum), and sirsat (Annona muricata) (Figure 3).

Fruit trees are mostly cultivated in homegarden as fruit source and microclimate controller (temperature and light intensity controller). In addition, some of species are native...
trees with potentials of medicine, timber, and food, such as klerek (Sapindus rarak), pule (Alstonia scholaris), wangkal (Albizia procera), turi (Sesbania grandiflora), and belinjo (Gnetum gnemon). However, these species were chosen by only few respondents because they preferred tree species which has economic benefits for their life such as commercial timber trees. For example, sengon (P. falcata) is a timber tree that can be harvested at the age of 5-6 years with wood volume reach 300 m$^3$ per hectare with potential income of 240 million rupiah (Mulyana and Asmarahman 2012). In contrast, although species like klerek (S. rarak) has the potential for batik material, cloth cleaner, soap, biopesticides, acne treatment, shampoo, and shade plant and can be harvested at 5-6 years (Udarno 2012), but this species is rarely cultivated by community since it has limited commercial value.

Figure 2. Basic data of respondents (age and education level) at the studied areas in Gubrih sub-watershed, Bondowoso District

Figure 3. Species of tree (45 species) selected by local communities for rehabilitation programs in Gubrih sub-watershed, Sampean watershed, Bondowoso District, East Java Province, Indonesia
There were 17 species listed in the questionnaire that were not chosen by respondents with most of them are native trees found at the forest of the reference site. Reference site is site with ecosystem that has similar biotic and abiotic conditions with the land to be restored or rehabilitated. In this study, we referred to trees found at protected forest of RPH Sentul, Probolinggo, East Java that has similar ecosystem condition with Sampenan watershed (Darmayanti and Fiqua 2017). These species include Bischofia javanica, Buchanania arborescens, Cassia javanica, Diospyros blancoi, Dracontomelon dao, Dyssoxylum gaudichaudianum, Erythrina orientalis, Ficus variegata, Litsea glutinosa, Madhuca longifolia, Michelia alba, Parkia timoriana, Peltrophorum pterocarpum, Pipturus sp., Pterocymbium tinctorium, Saraca indica, and Sterculia cordata. Although these species have biodiversity values, these species were not chosen by the respondents as they were not familiar with these species. In the other perspective, they assumed that these species lack of economic potentials. Nonetheless, these tree species have ecological values. Bisbul (Diospyros blancoi), cempaka (Michelia alba), gerok ayam (Buchanania arborescens), gintungan (Bischofia javanica), kedawung (Parkia timoriana), kedoya (Dyssoxylum gaudichaudianum), kelumpang (Sterculia cordata), walnuts (Canarium vulgare), nyamplung (Calophyllum inophyllum), krau (D. dao), saga (Peltrophorum pterocarpum) are among 25 tree species that have high potentials in carbon sequestration in dry lowlands ecosystem (Danarto and Yulistyarini 2019). They are also commonly found in water springs of lowland ecosystem so that the existence of these trees is very important for water conservation (Soejono et al. 2011).

Species of trees with potentials for timber and fruits were chosen by many respondents because these species have economic values. Sengon is one of timber tree categorized as fast-growing species so that it is widely cultivated by local community in Gubri sub-watershed (Irawanti et al. 2017). Sengon is native to Indonesia, Papua New Guinea, Solomon Island, and Australia. This species can grow in a variety of habitat from dry to moist soil, even in acidic soil with good drainage. In Java, this species can be found on various types of soil with altitude 0-1200 m above sea level (Soerianegara and Lemmens 1993). Besides of sengon, other species which has timber potential in Bondowoso are teak (T. grandis), sonokeling (Dalbergia latifolia), and gmelina (G. arborea). Both jati and sonokeling are species that contribute to high timber production in Bondowoso if compared to other timber trees such as sengon, mahogany, and pine. Data from BPS Bondowoso in 2017 showed that production of timber in 2016 in term of teak commodities reached 917.9 m³ with sonokeling wood production reached 3,049 m³ (BPS Bondowoso 2017). Teak has been chosen by many people as a long-term investment and has high economic benefits. Teak trees are able to grow at altitudes of 0-1200 m above sea level with an average annual temperature of 14-36°C. This tree species is native to India, Indonesia, Laos, Myanmar, Thailand and is able to grow in dry to moist habitats with rainfall of 600-4000 mm/year. The most suitable soil type is deep, well-drained soil, fertile alluvial-kolluvial soil with a pH of 6.5-8 with high levels of calcium and phosphorus (Orwa et al. 2009). Most commercial timber trees planted in Bondowoso are cosmopolitan tree species that has wide adaptation to various climatic conditions and soil types.

Our findings suggest that there is a gap between ecological perspective and socio-economic interests in the selection of species for land rehabilitation, especially in watershed landscape. This is indicated with a mismatch between the list of species with ecological-biodiversity values and species with socio-economic preferences. Previous study in Rejoso watershed, Pasuruan District, East Java, local communities have several criteria for selecting tree species for rehabilitation under PES (Payment for Ecosystem Service) scheme (Leimona et al. 2018). These include the tree species must be suitable with local habitat, it has good prices and accessible market to deliver high revenues, it must have benefit for domestic consumption and the species possesses environmental and conservation values. Also, local communities prefer trees species that are consistent with their current farming system. Fruit and timber trees were preferred by smallholders in the downstream while agroforestry mostly cultivated in the upstream (Leimona et al. 2018).

In various rehabilitation programs of degraded areas in Indonesia, tree species such as sengon, teak, gmelina, and jabon are widely planted by communities because these species have economic values. However, the lifetime of these species is not long because they are harvested for its timber yield so that the rehabilitation goals for environmental improvement are not achieved (Soejono and Budiharta 2013). One of alternative for rehabilitation of degraded areas is using non-timber producing species which has long-term economic and environmental improvement potentials. From the selection of the villager population at the study sites, we propose several species of non-timber that can be used for land rehabilitation in the region including durian (D. zibethinus), avocado (P. americana), coffee (C. robusta), jackfruit (A. heterophyllus), mango (Mangifera indica), water guava (Syzygium aqueum), candlenut (Aleurites moluccana), petai (Parkia speciosa), rambutan (N. lappaceum), jeruk bali (C. maxima), and lamtoro (L. leucocephala). When cultivated, these species can be combined to form multi-strata agroforestry which not only can deliver non-timber products but also contributes to conserve water and soil (Budiharta et al. 2016).

Planting tree species for rehabilitation needs to consider habitat suitability, soil type, texture, soil structure and depth, climate, and water use efficiency (Soejono et al. 2011). Based on interviews with local community at the research location supported by literature studies from Orwa et al. (2009), Krisnawati et al. (2011), Harja et al. (2009), Soerianegara and Lemmens (1993), suitable habitat of trees species selected by the local community can be divided into three ranges of altitudes, including low (0-400 m asl), medium (500-900 m asl) and high altitudes (mountainous with altitude > 900 m asl). Most of the trees species chosen by the local community at the studied areas can be planted from lowland to highland areas, including sengon (P.
façaturia), gmelina (G. arborea), teak (T. grandis),
avocado (P. americana), jack fruit (A. heterophyllus),
mahogany (S. macrophylla), bread fruit (A. altillis),
mangoes (Mangifera indica), guava (S. aqueum), candle nut
(Aleurites moluccana), and lamtoro (L. leucocelpha). On
the other hand, preferred species that can be cultivated
from lowland up to medium altitudes are durian (D.
zibethinus), guava (S. aqueum) and rambutan (N.
Lappaceum). While jeruk bali (C. maxima) can only be
cultivated in lowland ecosystem. Suitable habitat for
preferred trees by local community is showed in Table 2.

The research location has an average rainfall of 1000-
2500 mm/year with soil is categorized as clay and loam
soil. Durian (D. zibethinus) is cultivated by villager from
middle to highland combined with other fruit trees such as
avocado (P. americana), coffee (C. robusta), banana
(Musa acuminate), rambutan (N. lappaceum), and jeruk
bali (C. maxima). Bondowoso is one of district that
supplies durian in Indonesia with total production of
11.196 tons (Fitri and Islahudin 2018). Other species such
as coffee (C. robusta) are cultivated from middle
to highland and can be combined with other fruit trees within
agroforestry system. Coffee is suitable to cultivate within
the range of altitude from 1300 to 3000 m asl with
temperature of 15-25°C and average rainfall 500-2000
mm/year. Soil classes suitable for coffee cultivation are
loamy soil with deep solum, slightly acid, and well
drainage. The soils should be rich in nutrients especially
potassium with generous supply of organic material (Orwa et
al. 2009). Agroecologically, both plants are suitable
cultivated in Bondowoso. Previous study showed that
avocado, durian, clove and perennial crop that combined in
agroforestry systems in Bondowoso are profitable with
NPV (Net Present Value) of Rp.21,483.580 per hectare
(Hariyati 2013).

Local community perception toward land rehabilitation

The results of the survey indicated that local
community in Gubrih sub-watershed, Sampean watershed
has a different perception regarding land rehabilitation in
their area (Figure 4). It showed that most people in the area
understand the importance of trees in their lives and trees
deliver benefits to them. However, there were some
respondents saying that trees are not important for their
lives and they also have poor knowledge about the benefits
of trees. Perceptions of the importance of trees for local
community in Gubrih Sub-watershed are shown in Figure
4.

The perception of local people about the importance of
trees in their lives indicate that local people use trees for
various needs, including as income sources, conserving
spring water, and disaster mitigation with most of them
stated that trees are important for the purpose to increase
income. Bondowoso is one of the poor region (daerah
tertingga) in Indonesia with problems including low
human development index, poverty, and lack of basic
facilities, such as health, education and road infrastructure
(Bondowoso Spatial Plan Agency 2011; Puspasari and
Koswara 2016).

Community welfare in Bondowoso needs to be
increased to reduce the poverty level. There are 90,08% of
total land area in Bondowoso used for agricultural land,
including rice field, non-rice crop field (tegalan),
plantations, forestry, swamps, and ponds. Most of villagers
in Bondowoso work in the sector of agriculture, forestry,
and fisheries. Commodities cultivated in plantations in
Bondowoso include coconut, areca nut, kapok, cashew nut,
arabica coffee, robusta coffee, cloves, kasturi tobacco,
sugar cane, and tobacco, whereas fruit species include
mango, banana and durian (BPS Bondowoso 2018). Since
most of the community perceptions in the survey locations
use trees and plants as a source of income, this can be
combined with efforts to rehabilitate land by focusing on
species with multiple benefits, not only to improve
environment quality (i.e. ecological objective) but also to
enhance community’s welfare (socio-economic objective).
The potential land management system to support
rehabilitation efforts in the study region including
plantation of timber species and agroforestry system which
can be implemented in land management currently under
non-rice crop field (tegalan).

Influencing variables of community’s preference

Land topography and access influenced the preference
of land use systems by local community in Gubrih sub-
watershed. Based on the results of Chi-square Pearson
statistical analysis, there is a correlation between
topography and the selection of land management systems
by local community (p-value<0.05). Dryland agricultural
system, either in the form of padi gogo rice field or other
crops field (tegalan) were mostly applied by villagers from
low to medium altitudes, and on flat locations, but this land
use was rarely applied on steep topography in which most
respondents preferred agroforestry (Figure 5).

There is also a correlation between variable of access
and the selection of land management systems by
community with Chi-square Pearson value of 10.33
(p-value<0.05). For all categories of access (i.e. easy,
moderate and difficult), many villagers preferred plantation
of timber species and agroforestry system because they
assume that both systems of land use are profitable (Figure
6). Yet, for all categories of access, land use system of
dry land rice cultivation (padi gogo) was still chosen by the
villagers although the percentage is smaller than plantation
of timber species and agroforestry.

The finding of the relationship between land
management and accessibility is in accordance with other
studies. The more difficult is the access of a land
management system, the higher is the likelihood a land
being managed for tree-based land-use systems such as
forest and agroforestry. Vice versa, the easier is the access
to transportation, the more likely a land is managed under
intensive agriculture, such as rice field and non-rice crop
field (tegalan). Several factors that influence land use
functions in watersheds include the presence of
infrastructure, agricultural expansion, timber extraction.
Access of transportation triggers migration and forest
clearing for plantations (Geist and Lambin 2002; Verbist et
Table 2. Environmental suitability for 14 species preferred by local community in Gubrih sub-watershed, Sampean watershed, Bondowoso District, East Java Province, Indonesia

<table>
<thead>
<tr>
<th>Species</th>
<th>Altitude (m asl)</th>
<th>Soil type</th>
<th>Potentials</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paraserianthes falcataria</td>
<td>0-1200</td>
<td>Deep, well-drained fertile soils, such as friable clay loam. Prefers alkaline to acid soils.</td>
<td>Timber</td>
<td>Orwa et al. (2009)</td>
</tr>
<tr>
<td>Gmelina arborea</td>
<td>0-1200</td>
<td>Preference for moist, fertile, freely drained soils; acid soils, calcareous soils and laterite soils.</td>
<td>Timber</td>
<td>Orwa et al. (2009)</td>
</tr>
<tr>
<td>Tectona grandis</td>
<td>0-1200</td>
<td>Their most suitable soil is deep, well-drained, fertile alluvial-colluvial soil with a pH of 6.5-8 and a relatively high calcium and phosphorous content. The quality of growth, however, depends on the depth, drainage, moisture status and the fertility of the soil. Teak does not tolerate waterlogging or infertile lateritic soils.</td>
<td>Timber</td>
<td>Orwa et al. (2009)</td>
</tr>
<tr>
<td>Persea americana</td>
<td>0-2500</td>
<td>Requires a well-drained aerated soil. A pH of 5-5.8 is optimal for growth and fruit yield.</td>
<td>Fruit</td>
<td>Orwa et al. (2009)</td>
</tr>
<tr>
<td>Artocarpus heterophyllus</td>
<td>0-1600</td>
<td>Deep, alluvial, sandy-loam or clay loam soils of medium fertility, good drainage and a pH of 5-7.5. This species tolerance to saline soils</td>
<td>Timber, fruit and vegetable</td>
<td>Orwa et al. (2009)</td>
</tr>
<tr>
<td>Swietenia macrophylla</td>
<td>0-1500</td>
<td>Well-drained soils.</td>
<td>Timber</td>
<td>Orwa et al. (2009)</td>
</tr>
<tr>
<td>Artocarpus altilis</td>
<td>0-1550 (optimum growth at 600-650)</td>
<td>Alluvial and coastal soils, deep, fertile, well-drained sandy loam or clay loam soils.</td>
<td>Timber, fruit and vegetable</td>
<td>Orwa et al. (2009)</td>
</tr>
<tr>
<td>Mangifera indica</td>
<td>0-1200</td>
<td>Mango trees thrive in well-drained soils with pH ranging from 5.5 to 7.5 and are fairly tolerant of alkalinity. For good growth, they need deep soil to accommodate the extensive root system.</td>
<td>Fruit</td>
<td>Orwa et al. (2009)</td>
</tr>
<tr>
<td>Syzygium aqueum</td>
<td>0-1200</td>
<td>The trees prefer heavy soils and easy access to water instead of having to search for water in light deep soils.</td>
<td>Fruit</td>
<td>Panggabean (2016)</td>
</tr>
<tr>
<td>Aleurites moluccana</td>
<td>0-1200</td>
<td>Sandy, clay, loam soil with pH 5-8.</td>
<td>Spices</td>
<td>Krisnawati et al. (2011)</td>
</tr>
<tr>
<td>Leucaena leucocephala</td>
<td>0-1500</td>
<td>Optimal growth on calcareous soils but can be found on saline soils and on alkaline soils up to pH 8; it is not tolerant of acid soils or waterlogged conditions. <em>L. leucocephala</em> is known to be intolerant of soils with low pH, low phosphorus, low calcium, high salinity, high aluminum saturation and water-logging and has often failed under such conditions.</td>
<td>Fruit, firewood</td>
<td>Orwa et al. (2009)</td>
</tr>
<tr>
<td>Durio zibethinus</td>
<td>300-800</td>
<td>Deep soil, well-drained, light sandy or loamy soil.</td>
<td>Fruit, timber</td>
<td>Orwa et al. (2009)</td>
</tr>
<tr>
<td>Nephelium lappaceum</td>
<td>0-600</td>
<td>Clay loam soil, pH 5-6.5.</td>
<td>Fruit</td>
<td>Orwa et al. (2009)</td>
</tr>
<tr>
<td>Citrus maxima</td>
<td>0-400</td>
<td>Tolerate from coarse sand to heavy clay</td>
<td>Fruit</td>
<td>Orwa et al. (2009)</td>
</tr>
</tbody>
</table>

Figure 4. Perception of local community on the benefit of trees in their life

Figure 5. Land use system preferred by local community based on categories of land topography
Based on interviews with respondents, timber plantation and agroforestry were considered to have economic advantages compared to other land uses. Agroforestry system is ecologically and economically beneficial. Agroforestry system at the survey location is a mixed system of combination of several species of fruit trees and seasonal crops. The villagers at the survey location stated that the agroforestry system increased income of their life. Difficult access to transportation to traditional markets causes local communities preferred for agroforestry and timber plantation for economic investment purposes.

Agroforestry increases community income and environmental services compared to conventional farming systems (Mercer et al. 2014). Previous study showed that coffee farming in Bondowoso is beneficial with R/C is 1.85. Other study showed that commercial agroforestry in India is profitable with Benefit to Cost (B/C) ratio is 6.59 for annual crop-based tree agroforestry (Sangeetha et al. 2015). Case study in East Kalimantan, vanilla and agarwood agroforestry are also profitable with profit rate of 15% and IRR of 21.5% (Kunio and Lajhite 2015). Agroforestry contributes to the income of farmers in Sukoharjo Pringsewu Village with benefit percentage of 88.31% (Olivi et al. 2015).

Conclusion

Of the 62 tree species listed in the questionnaire, there were 45 species of trees selected by respondents in Gubrh sub-watershed with 13 species were highly preferred. The respondents have understood the importance of trees as a source of income as well as a measure to conserve spring water and mitigate disasters, such as landslides and floods. This is strengthened with land-use systems they selected which prefer tree-based land-use systems such as plantation of timber species and agroforestry. This preference is influenced by access to transportation and land topography. The findings of this study suggest that there is opportunity in rehabilitating degraded lands in Sampean watershed using tree species preferred by local community under the land use system of timber plantation or agroforestry. List of species resulted from this study can provide insights when establishing nurseries and producing seedlings for rehabilitation programs.

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![Figure 6. Land use system preferred by local community based on categories of location access.](image-url)


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