Selection of agroforestry tree-base participatory and ecological approach in Central Kalimantan, Indonesia

E I Purnawan1*, R Jemi2, H Kasim3, L A Uthan4, J Regalino3 and A Hamidi5

1 Postgraduate Student in Natural Resources Management at the University of Palangka Raya, Indonesia
2 Department of Forestry, Faculty of Agriculture, University of Palangka Raya, Indonesia
3 Borneo Orangutan Survival Foundation-Mawas, Indonesia
4 Student of International Relations, Faculty of Social and Political Sciences, Dipenegoro University, Indonesia
5 Fauna & Flora International, Indonesia

Abstract. This study investigates the selection of agroforestry tree species based on a participatory approach and an ecological approach in Humbang Raya village and Tumbang Mantuhe village. This study method was carried out using a participatory approach through Focus Group Discussion (FGD) activities and an ecological approach through the identification of tree species in open and closed forests. The results of the FGD selected tree species in Humbang Raya village as many as 17 tree species and in Tumbang Mantuhe village as many as five tree species. The results of the identification of tree species in Humbang Raya village in closed forest amounted to 34 tree species, while in open forest there were 10 tree species. In Tumbang Mantuhe village in closed forest there are 29 species of trees and open forest five species of trees. It was concluded that the selected tree species to be planted on agroforestry land in Humbang Raya village and Tumbang Mantuhe village each had 4 tree species.

Keywords: Agroforestry; participatory; FGD; ecology; species identification.

1. Introduction
The community around the conservation area is a supporter of the conservation work program. But if it is not managed and cooperated in a program of conservation activities, it can become a threat. In fact, the implementation of community empowerment around the forest is often not directed and the program even fails. Due to the lack of involvement of the community around the forest, who were involved from the start in planning the program of activities. So that the program of activities to be carried out is not relevant to the needs of the community around the forest. The species selection process which is centralized and does not care to the wishes of local communities has failed to address conservation targets and local interests in livelihood development [1]. Efforts that can be made to anticipate this problem is to make a strategic plan in the management of conservation areas based on community empowerment. According to [2], that community involvement can be in the form of Education through training, Active participation in gathering information and Participation in providing alternative plans and proposals to the government. One of the community empowerment activities is the selection of agroforestry trees based on community participation (participatory approach), but an ecological approach also needs to be carried out. A participatory approach is used to find out which tree species are preferred by the community. An ecological approach was used to find out the right tree species, according to their edaphic conditions. With this background, it’s necessary to study participatory and
ecological approaches to select the right Species of agroforestry trees in the conservation program areas in Humbang Raya village and Tumbang Mantuhe village so that later the tree species planted can be grow well and conservation program activities in the area it’s also can be work as expected.

2. Study Methods

2.1 Study time and location
The study was carried out for 3 months from September to December 2020. The administrative location of this research is in Central Kalimantan, precisely in the area Hubang Raya Village, Mantangai District, Kapuas Regency and Tumbang Mantuhe Village, Manuhing Raya District, Gunung Mas Regency. Geographically, Hubang Raya village is located at 1°53'03.6"S 114°08'15.6"E and Tumbang Mantuhe village is at 1°20'08.5"S 113°18'43.2"E.

2.2 Data collection technique

2.2.1 Selection of agroforestry tree species through a participatory approach. The selection of tree species was carried out using a participatory approach based on farmers traditional knowledge about various tree functions and tree rankings through Focus Group Discussions (FGD) and non-participant observations [3]. The number of FGD participants in each village in this study is 15 farmers. The FGD group usually consists of 10 farmers who have knowledge of traditional tree species [4]. The data collected is descriptive qualitative, tabulated and ranked. The selection of tree species refers to several criteria [3] as shown in Table 1 below.

| Benefit Criteria | Specific | Specific Benefit |
|------------------|----------|------------------|
| Economy          | 1. Fruit | Fruit production, marketability, resistance to pests |
|                  | 2. Firewood | Sprout regeneration ability, wood hardness, low moisture retention, fast drying, fast growth |
|                  | 3. Fodder | Leaf production, tenderness, nutritional content, quick drying |
|                  | 4. Wood | Hardness of wood, marketability, colour of wood |
|                  | 5. Medicine | Effectiveness, wide application, medicine production |
|                  | 6. Other income | Honey production, other food production, commercial value of seeds and seedlings, oil production |
| Environment      | 7. Soil Fertility | Amount of litter, root nitrogen-fixing ability, fast biodegradation of leaves |
|                  | 8. Erosion control | Widely spread roots, water retention ability (wide leaves, many branches), large crown area |
|                  | 9. Growth | Fast growth |
|                  | 10. Horizontal influence | Light penetration, horizontal branch spread, horizontal root spread |
|                  | 11. Sociability | Lack of negative effects on other trees, no positive effects on other trees |
| Management       | 12. Breeding ease | Ease of use seeds, roots, cuttings |
|                  | 13. Manageability | Resistance to diseases and pests, less need for weeding and fertilizing |
2.2.2 Selection of agroforestry tree species through ecological approach. Selection of species with an ecological approach is carried out by identification species of vegetation through the creation of observation sample plots that exist in open forest and close forest in each study location. Accuracy of scientific names was obtained by using a comparative method, namely comparing the herbarium samples of tree species found in the field with references to tree species identification books. Observational sample plots were determined using the purposive sampling method. The plots was chosen based on considerations of land cover representation and accessibility in the field. The number of plots in closed forest is 4 plots and open forest is 4 plots. The plots alternated from one plot to another and the distance between the plots is 20 m. The observation plot area of 0.12 ha is sufficient to describe the composition of the vegetation composition [5]. The measuring plots for each growth stage were as follows: seedlings with a plot size of 2 x 2 m, saplings with a plot size of 5 x 5 m, poles with a plot size of 10 x 10 m, trees with a plot size of 20 x 20 m [6].

2.3 Data analysis
Data analysis was carried out by comparing the data on selected tree species based on the data FGD (participatory approach) and the data from observations of vegetation species around forest in the research location (ecological approach). The tree species selected during the FGD with members of the farmer group and also found in the forest during vegetation observation, will be the priority trees recommended as agroforestry trees in this study.

3. Results and discussion

3.1 Selection of agroforestry tree species with a participatory approach

3.1.1. Participatory approach in Humbang Raya Village. Based on the results of discussions and assessment of the selection agroforestry tree species with the participatory approach in the Hubang Raya village, there were 5 tree species selected by farmers. The results of the ranking of selected tree species are shown in Table 2.

| Local Name | Scientific name     | Rank |
|------------|---------------------|------|
| Durian     | Durio zibethinus    | 1    |
| Cempedak   | Artocarpus integer  | 2    |
| Tampang    | Cotylelobium sp     | 3    |
| Payait     | Xerospermum sp      | 4    |
| Gandis     | Garcinia parvifolia | 5    |

Based on Table 2, in particular the selection of species for participatory agroforestry activities shows that the villagers know the species they will plant. As well as knowing the characteristics of both the economic, environmental and management aspects. According to [7], it is stated that the participatory selection of local vegetation species by the community in agroforestry activities is very supportive and effective for the restoration of ecosystem functions and biodiversity on degraded land.

3.1.2. Participatory Approach in Tumbang Mantuhe Village. The results assessment of the selection agroforestry tree species with the participatory approach in the Tumbang Mantuhe village, there were 5 tree species selected by farmers. The results of the ranking of selected tree species are shown in Table 3.
Table 3. Results of ranking of agroforestry tree species based on a participatory approach in Tumbang Mantuhe village.

| Local Name | Scientific name            | Rank |
|------------|----------------------------|------|
| Sungkai    | *Peronema canescens*       | 1    |
| Durian     | *Durio zibethinus*         | 2    |
| Jengkol    | *Archidendron pauciflorum* | 3    |
| Cempedak   | *Artocarpus integer*       | 4    |
| Paken      | *Durio kutejensis*         | 5    |

Based on Table 3, almost all species of agroforestry trees selected by farmers are fruit trees, this is because farmers prioritize tree species that can also function to maintain food security in the village, and the species of agroforestry trees selected by farmers are fruit trees that has a sale value.

3.2 Selection of agroforestry tree species with an ecological approach

3.2.1 Ecological Approach in Humbang Raya Village. The results of the ecological approach based on the data observations of vegetation species carried out in closed and open forest areas in Humbang Raya Village are presented in Table 4 below.

Table 4. Species of Vegetation in the Closed Forest and Open Forest in Humbang Raya Village.

| Humbang Raya Village | Closed Forest | Open Forest |
|----------------------|---------------|-------------|
|                      | 1. *Adinandra sp.* | 1. *Artocarpus kemandoo* |
| 2. *Agathis borneensis* | 14. *Dipterocarpus tempehes* | 2. *Calophyllum pisiferum* |
| 3. *Alphonsea sp.* | 15. *Dryobalanops rappa* | 27. *Shorea macroptera* |
| 4. *Asodaphne sp.* | 16. *Dryobalanops sumatrensis* | 28. *Shorea sp.* |
| 5. *Beilschmiedia sp.* | 23. *Palaquium sp.* | 7. *Nephelium sp.* |
| 6. *Calophyllum sp.* | 19. *Lithocarpus cantleyanus* | 32. *Xylopia ferruginea* |
| 7. *Cotylebium sp.* | 20. *Lithocarpus sp.* | 33. *Xerospermum noronhianum* |
| 8. *Cratoxylum arborescens* | 31. *Xylopia ferruginea* | 8. *Syzygium sp.* |
| 9. *Cyathocalyx sp.* | 21. *Microcos hirsuta* | 33. *Xerospermum sp.* |
| 10. *Dacryodes costata* | 22. *Nephelium maingayi* | 9. *Timonius flavescens* |
| 11. *Diplospora sp.* | 23. *Palaquium sp.* | 10. *Vitex pinnata* |
| 12. *Dipterocarpus applanatus* | 24. *Polalthia sp.* | |

3.2.2 Ecological Approach in Tumbang Mantuhe Village. The results of the ecological approach based on the data observations of vegetation species carried out in closed and open forest areas in Tumbang Mantuhe village are presented in Table 5.
### Table 5. Species of Vegetation in the Closed Forest and Open Forest in Tumbang Mantuhe Village.

| Village                  | Closed Forest                                           | Open Forest                                           |
|--------------------------|---------------------------------------------------------|-------------------------------------------------------|
|                          | 1. Albizia sp.                                         | 11. Gironniera nervosa                                 |
|                          | 2. Antidesma sp.                                       | 21. Magnolia sp.                                      |
|                          | 3. Archidendron                                         | 1. Callicarpa glabrifolia                              |
|                          | 4. Artocarpus integer                                   | 2. Fordia splendidissima                               |
|                          | 5. Artocarpus rigidus                                   | 22. Nephelium sp.                                     |
|                          | 6. Campnosperma squamatum                               | 23. Pternandra galeata                                |
|                          | 7. Cartoxylum arborescens                               | 3. Pertusadina sp.                                    |
|                          | 8. Dillenia borneensis                                  | 24. Rhus sp.                                          |
|                          | 9. Diospyros sp.                                        | 4. Rinorea sp.                                        |
|                          | 10. Fordia splendidissima                               | 25. Syzygium antisepicum                               |
|                          | 12. Gironniera nervosa                                  | 5. Vitex pinnata                                      |
|                          | 13. Gordonia sp.                                        |                                                       |
|                          | 14. Hancea griffithiana                                 |                                                       |
|                          | 15. Hevea brasiliensis                                  |                                                       |
|                          | 16. Ixonanthes icosaundra                               |                                                       |
|                          | 17. Lithocarpus sp.                                     |                                                       |
|                          | 18. Lophopetalum beccarianum                            |                                                       |
|                          | 19. Litsea sp.                                          |                                                       |
|                          | 20. Macaranga sp.                                       |                                                       |

### Table 6. Selected agroforestry tree species in Humbang Raya Village and Tumbang Mantuhe Village

| Village                  | Local Name | Scientific name                  |
|--------------------------|------------|----------------------------------|
| Humbang Raya             | Nangka     | Artocarpus kemando               |
|                          | Tampang    | Cotylelobium sp.                 |
|                          | Laban      | Vitex pinnata                    |
|                          | Payait     | Xerospermum noronhianum          |
| Tumbang Mantuhe          | Cempedak   | Artocarpus integer               |
|                          | Karet      | Hevea brasiliensis               |
|                          | Laban      | Vitex pinnata                    |
|                          | Hantangan  | Campnosperma auriculatum         |

3.3 Recommended agroforestry tree species
The recommended tree species for agroforestry management are the result of integration of the wishes of farmer groups that adapted to their ecological conditions. The following selected tree species recommended for agroforestry management in Humbang Raya village and Tumbang Mantuhe village can be seen in Table 6.

Table 6 explains that at the study location in Humbang Raya village there are four selected agroforestry trees species, namely *Artocarpus kemando*, *Cotylelobium sp.*, *Xerospermum noronhianum* and *Vitex pinnata*. The four type of trees are tree species that have the potential to be developed in agroforestry according to economic, environmental and management benefits. At the study site in open forest *Artocarpus kemando* was found at sapling and tree level, *Cotylelobium sp.* was found at the sapling level, *Vitex pinnata* found at seedling level and also a pioneer species. At the study site in close forest *Xerospermum noronhianum* was found at pole level.

Table 6 also explains that at the study site in Tumbang Mantuhe, there are four selected agroforestry tree species, namely Artocarpus integer, Hevea brasiliensis, Vitex pinnata and Campnosperma squamatum. The four species of trees are tree species that have the potential to be developed in agroforestry in Tumbang Mantuhe village according to economic, environmental and management benefits. Hevea brasiliensis is a naturalized tree species at the study site, this species is found in closed forest vegetation. Hevea brasiliensis is a species of cultivated tree developed by the people of Tumbang Mantuhe village as an alternative for economic income. Vitex pinnata is commonly found in open forest vegetation and is a pioneer species. Campnosperma auriculatum is found in closed forest at the tree level, this species of tree has a large canopy so it is good for planting on agricultural tree species that
require a lot of shade. Campnosperma auriculatum is able to grow on three types of soil (podsol, acrisol and cambisol) with a survival rate of 80% [8] and also fast-growing tree species.

4. Conclusion
Based on the results and wetting of the aspect of selecting agroforestry tree species in the villages of Humbang Raya and Tumbang Mantuhe, the following conclusions can be drawn:

a) Selection of agroforestry tree species with a participatory approach:
   - In Humbang Raya village: Durio zibethinus, Artocarpus integer, Cotylelobium sp., Xerospermum sp. and Garcinia parvifolia.
   - In Tumbang Mantuhe village: Peronema canescens, Durio zibethinus, Archidendron pauciflorum, Artocarpus integer and Durio kutejensis.

b) Identification of vegetation species in closed and open forests:
   - In Humbang Raya village there are 34 species of vegetation in closed forest and in open forest there are only 10 species of trees.
   - In Tumbang Mantuhe village there are 29 species of vegetation in the closed forest and in the open forest there are only 5 species of trees.

c) Tree species are recommended for agroforestry:
   - In Humbang Raya village: Artocarpus kemando, Cotylelobium sp., Xerospermum noronhianum and Vitex pinnata.
   - In Tumbang Mantuhe village: Artocarpus integer, Hevea brasiliensis, Vitex pinnata and Campnosperma squamatum.

5. References
[1] Xu J, van Noordwijk M, He J, Kim K J, Jo R S, Pak K G, Kye U H, Kim J S, Kim K M, Sim Y N, Pak J U, Song K U, Jong Y S, Kim K C, Pang C and Ho M H 2012 Participatory agroforestry development for restoring degraded sloping land in DPR Korea. Agroforestry Syst 85 291-303
[2] Sanusi H and Hidayah A K 2015 Pengkajian potensi desa dengan pendekatan partisipatif di Desa Mawai Indah Kecamatan Batu Ampar Kabupaten Kutai Timur. Jurnal Agrifor 14 185-196
[3] He J, Ho M H and Xu J 2015 Participatory selection of tree species for agroforestry on sloping land in North Korea. Mountain Research and Development 35 318-327
[4] Hennink M M 2014 Understanding focus group discussions. New York Oxford University Press
[5] Mariaty, Afitah I and Santosa P B 2019 Tingkat keanekaragaman hayati lahan bekas terbakar di Taman Nasional Sebangau & kawasan hutan dengan tujuan khusus (KHDTK) Tumbang Nusa. Daun Jurnal Ilmiah Pertanian dan Kehutanan 6 129–39
[6] Nugroho A W 2011 Struktur vegetasi dan komposisi jenis pada hutan rawa gambut di Resort Habaring Hurung, Taman Nasional Sebangau, Kalimantan Tengah. Prosiding Seminar Hasil-Hasil Penelitian BPTKSDA Samboja pp 201-210
[7] Lu Y, Ranjitkar S, Harruson R D, Xu J, Ou X, Ma X and He J 2017 Selection of native tree species for subtropical forest restoration in Southwest China. PLoS ONE 1-15
[8] Fathia A A 2019 Rehabilitasi lahan pada area bekas terbakar dengan jenis tanah yang berbeda di Kabupaten Gunung Mas Kalimantan Tengah. Media Konservasi 24 20-28

Acknowledgments
This study was funded by the Borneo Orangutan Survival Foundation (BOSF) Mawas Conservation Program. The authors would like to thank for field team has assisted in research activities.