SAMPLING DESIGN FOR TREES OUTSIDE FOREST IN INDONESIA

Ministry of Environment and Forestry of Indonesia

Food and Agriculture Organization

IPB University

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PREFACE

This report presents a study on 'Sampling Design for Trees Outside Forest (TOF) in Indonesia', which was conducted to support a new design of Indonesia's National Forest Inventory (NFI). This study aimed to recommend an appropriate sampling design for TOF that is required by the Ministry of Environment and Forestry (MoEF) of Indonesia to implement a new NFI system.

This study was financially supported by FAO that provides technical supports to the MoEF in redesigning a new NFI system. Therefore, I am deeply grateful to FAO in Indonesia, particularly Rajendra K. Aryal, Adam Gerrand, Rubeta Andriani, Oemi Praptantyo, and Febrilydia Ginting, for giving me an opportunity to conduct this study. I also grateful to the NFI project team of the MoEF, particularly Belinda Arunawati Margono, Judin Purwanto, Nurhayati, and Hanifah Kusumaningtyas, who provided valuable suggestions and necessary data and documents for writing this report.

This study would not have been possible without valuable inputs from numerous resource persons. I am grateful to FAO experts, i.e., Lauri Vesa, Timo Tokola, Marco Piazza, Gael Sola, Solichin Manuri, Abdul Mukti, and Edwin Nugroho for sharing their thoughts related to forest inventory. I also appreciate useful inputs from several provincial staff who participated in the TOF's pilot testings in West Kalimantan and West Java.

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SUMMARY

The existing National Forest Inventory (NFI) system of Indonesia provides forest resource data on state forested lands only. Meanwhile, the Government Regulation No. 23/2021 provided a mandate to the Ministry of Environment and Forestry (MoEF) to conduct NFI not only at state forests, but also at customary forests and private/community forests. This new mandate requires a new sampling design for conducting NFI at customary and community forests, which are collectively named as Trees Outside Forest (TOF) lands. This study was therefore aimed at proposing an appropriate sampling design for TOF lands.

This study was conducted by first discussing relevant criteria for defining TOF lands with the MoEF and other related parties. The main sampling design components, i.e., cluster-plot design and sample size (number of cluster-plot), were determined based on available community forest inventory data in Java. The TOF cluster-plot was designed to consist of three sample plots, in which each sample plot consists of three nested-plots that would provide fairly balanced contributions of small, medium, and large trees when estimating stand attributes. Appropriate number of cluster-plot was determined based on variation coefficients of stand attributes and targeted precision (i.e., allowable sampling error). In the final step, the proposed sampling design was tested at TOF lands in West Kalimantan and West Java.

Based on discussions with relevant parties, this study defined a TOF land as "a land classified as pure dry agriculture, mixed dry agriculture, dry shrub, or wet shrub according to the Indonesian land cover system with minimum area of 0.25 ha with trees higher than 5 m and canopy cover more than 10%". Appropriate cluster-plot for TOF land inventory consisted of three plots with a distance of 50 m. Each plot consisted of three nested subplots with a radius of 5 m for small trees with 5≤DBH<20 cm, a radius of 15 m for medium trees with 20≤DBH<35 cm, and a radius of 25 m for large trees with DBH≥35 cm. The pilot testing in West Kalimantan and Java confirmed that such cluster-plot design enable the field measurement of a cluster-plot within one day. To conduct NFI at TOF lands with a sampling error of 15%, this study recommended 70 cluster-plots for each island in Indonesia. The MoEF, however, might then adjust the number of cluster-plots by considering available budget and targeted precision for TOF lands inventory.

1. INTRODUCTION

1.1 Background

The Ministry of Environment and Forestry (MoEF) of Indonesia considered that the existing National Forest Inventory (NFI) system needs some improvements to match with the current regulatory frameworks and increasing international reporting requests. The Government Regulation No. 23/2021 provided a mandate to the MoEF to conduct NFI at state forests, customary forests, and private/community forests. Meanwhile, the existing NFI only covers the state forest lands. A comprehensive NFI system is thus required to generate national forest resource data not only from state forests, but also from customary and private forests. A new NFI system is also expected to be more cost efficient than the existing NFI system. Tiryana (2022) presented a review of the existing NFI system and a needs assessment for the new NFI system.

Since 2021 the MoEF has been collaborating with FAO to redesign the existing NFI system within a project called '*Strengthening Indonesian Forest and Land Monitoring for Climate Actions*'. An essential step in redesigning the NFI system was to formulate a new NFI design plan for Indonesian forests. Major parts of the new NFI design plan have been carried out by Vesa & Tokola (2023) who recommended a 'two-phase sampling for stratification'. In the first phase, a large number of sampling units are selected on a satellite image, and a subset of such sampling units is then selected for field measurements in the second phase. The sampling unit is a cluster-plot, consisting of three nested-circular plots with different subplot sizes for dry land and mangrove forests. Vesa & Tokola (2023) developed the new NFI sampling design based on the existing NFI data analysis that only covered state forest areas. Accordingly, they suggested that a separate sampling design should be developed for customary and private forests.

Despite the clear need for a comprehensive NFI system, the formal map boundaries of customary and private forests are not clear yet. Therefore, the first step in sampling design is to define the NFI scope for customary and private forests. This step must clarify whether it is appropriate to use customary and private forests terms, or another operational term must be used to suit the MoEF needs. The next steps in sampling design are to formulate an appropriate cluster-plot design (i.e., shape, size, and layout of plots), and to determine reliable sample size (i.e., minimum number of cluster-plots). The final step is to conduct pilot testings to assess the applicability of the proposed sampling design.

1.2 Purpose

This report aims to propose a sampling design plan for customary and private forests, which are collectively known as Trees Outside Forest (TOF) in the context of the new NFI system. Specifically, this report presents the results of consulting work on defining the TOF term, formulating cluster-plot design, determining the number of cluster-plot, and testing the proposed TOF's sampling design. This report is also aimed to complement the sampling design plan from Vesa & Tokola (2023) to provide a comprehensive NFI sampling design for Indonesia that covers all lands.

2. DEFINING TREES OUTSIDE FOREST (TOF)

A clear definition of Trees Outside Forest (TOF) is necessary for designing and implementing a new NFI system. A series of workshops (on 13, 14, and 21 March 2023), therefore, has been carried out with an NFI Working Group of the directorate of IPSDH (*Inventarisasi dan Pemantauan Sumber Daya Hutan*, the directorate of forest resource inventory and monitoring), MoEF. These workshops aimed to agree an operational definition of TOF and to define the NFI scope for TOF.

The main concern of the MoEF is that the new NFI system must cover customary and private forests, which are mostly established in private lands (outside of the state forest areas). The MoEF Decree No. 49/Kpts-II/1997 defined private/community forests as "forests owned by communities with a minimum area of 0.25 ha and the canopy cover of woody and/or other plants species of at least 50% or with a minimum tree density at the first planting year of 500 trees/ha". In the field, a community forest might be located in lawn/yard, dry field, paddy field, and garden of a household (**Figure 1**). The community forests (CF) are usually diverse from one region to another, but they could be classified into three stand types:

1) monoculture CF, where a CF only contains one tree species (e.g., *Falcataria moluccana* and *Tectona grandis*),
2) mixed-species CF, where a CF contains two or more tree species), and
3) agroforestry CF, where a CF is dominated by multi-purpose tree species to produce non-timber forest products (e.g., durian, betel nut, and coconut).

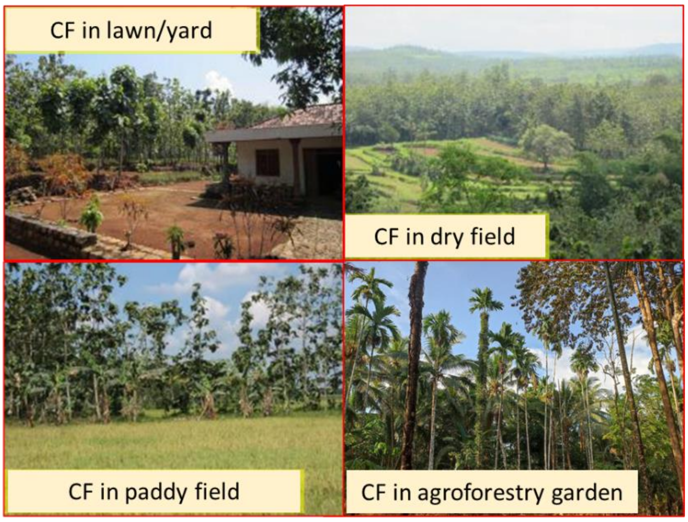


***Figure 1**. Community forest types*

Community forests in Indonesia provide economic and environmental benefits. Local communities manage their forests as a 'saving account' for household needs, in which some trees would be harvested when a household needs some money (Nugroho & Tiryana, 2013). Community forests may also provide renewable energy, in which stand biomass of 0.26–2.16 ton/ha/yr would generate electrical energy for 19–27 household (Suntana et al., 2012). These economic and environmental benefits confirm that the community forests are invaluable resources that must be included in the new NFI system.

Integrating community and customary forests in the new NFI system, however, poses challenges in defining their population areas, because there are no formal maps for the community and customary forests in Indonesia. Nevertheless, the MoEF recognized that the community and customary forests are two dynamic land use types that commonly exist in the non-forest classes of past and current land cover maps. Therefore, instead of focusing on inventoring the land use-based forest resource that might be change over time, the MoEF considered that the new NFI must be conducted on non-forest class areas of the existing land cover map to provide forest resource data that could not be provided by the existing NFI system. In the Indonesian land cover system, there are 7 forest classes and 16 non-forest classes (**Table 1**). The MoEF, however, considered that the new NFI for non-forest class areas only relevant for the following non-forest classes: Dry shrub (2007), Wet shrub (20071), Pure dry agriculture (20091), and Mixed dry agriculture (20092). A community forest inventory conducted by BPKH-XI & MFP (2009) confirmed that most of the community forests in Java located in two land cover classes: mixed dry agriculture (62%) and pure dry agriculture (20%).

Table 1*. The Indonesian land cover classes*

Code	Class	Category
2001	Primary dry land forest	Forest
2002	Secondary dry land forest	Forest
2004	Primary mangrove forest	Forest
20041	Secondary mangrove forest	Forest
2005	Primary swamp forest	Forest
20051	Secondary swamp forest	Forest
2006	Plantation forest	Forest
2010	Estate crop	Non-forest
20091	Pure dry agriculture	Non-forest
20092	Mixed dry agriculture	Non-forest
2007	Dry shrub	Non-forest
20071	Wet shrub	Non-forest
3000	Savanna and grasses	Non-forest
20093	Paddy field	Non-forest
50011	Open swamp	Non-forest
20094	Fish pond/aquaculture	Non-forest
20122	Transmigration areas	Non-forest
2012	Settlement areas	Non-forest
20121	Port and harbour	Non-forest
20094	Mining areas	Non-forest
2014	Bare ground	Non-forest
5001	Open water	Non-forest

After an intensive discussion with IPSDH staff, they agreed to use 'Trees Outside Forest (TOF)' term, instead of the community and customary forests, for the new NFI system. The TOF term is also used in the FAO's Forest Resource Assessment (FRA) to refer to "trees that are not in the forest category". The FAO's definition of TOF is broader, which might include agricultural, urban, and non agricultural/urban areas, than the MoEF's definition that is limited to the four non-forest classes. For the new NFI system, therefore, the proposed TOF definition is " *a land classified as pure dry agriculture, mixed dry agriculture, dry shrub, and wet shrub according to the Indonesian land cover system with minimum area of 0.25 ha with trees higher than 5 m and canopy cover more than 10%".* To identify TOF lands, one may use land cover map, forest function map, and high resolution satellite image (**Figure 2**). The IPSDH staff, however, realized that the use of 5 m tree height and 10% crown cover as TOF criteria would need further efforts in analyzing high resolution sattelite images, which are currently not available yet. Therefore, the land cover map is a main data source for identifying TOF lands as exemplified in **Figure 3**.

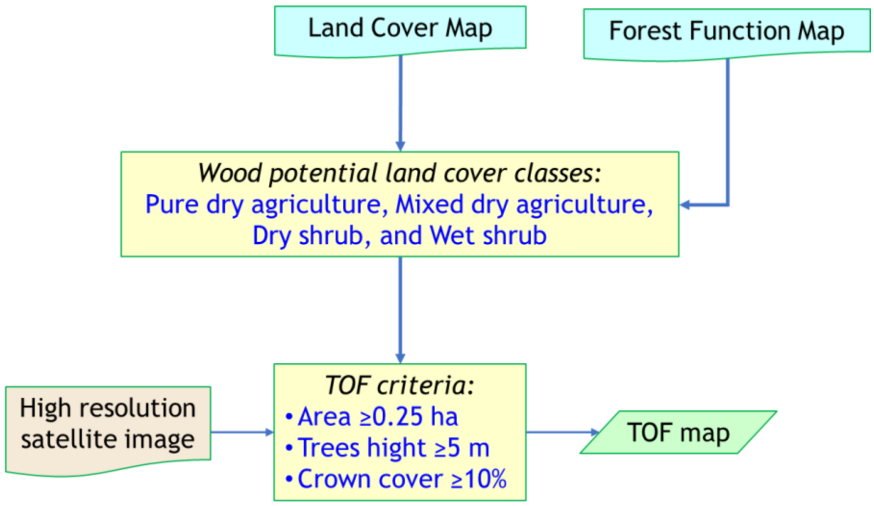


Figure 2*. A flowchart for identifying TOF lands*

Figure 3. TOF lands in Java based on the land cover map of 2022

3. CLUSTER-PLOT DESIGN FOR TOF

An essential NFI component is a cluster-plot design that enables an efficient field measurement. Commonly, an NFI uses cluster-plots as sampling units, consisting of several sample plots to capture local variabilities of forest resource (e.g., stand biomass) at certain location. For the new Indonesian NFI design, Vesa & Tokola (2023) has proposed a cluster-plot design for dry land and mangrove forests consisting of 3 sample plots as seen in **Figure 4**. The cluster-plot design of dry land forests is similar to that of mangrove forests, but the later has smaller nested-subplot sizes that correspond to the smaller diameter thresholds of mangrove forests. In addition, the distance between the sample plots of mangrove forests (i.e., 50 m) are also shorter than those of dry land forests (i.e., 100 m). Vesa & Tokola (2023) derived these cluster-plot designs based on cluster-plot simulations using the existing NFI data. However, they did not recommend a cluster-plot design for TOF. To complement the cluster-plot design of the new NFI, therefore, it is necessary to conduct a study on determining an optimal cluster-plot design for TOF. This chapter explains the methods and results of such study.

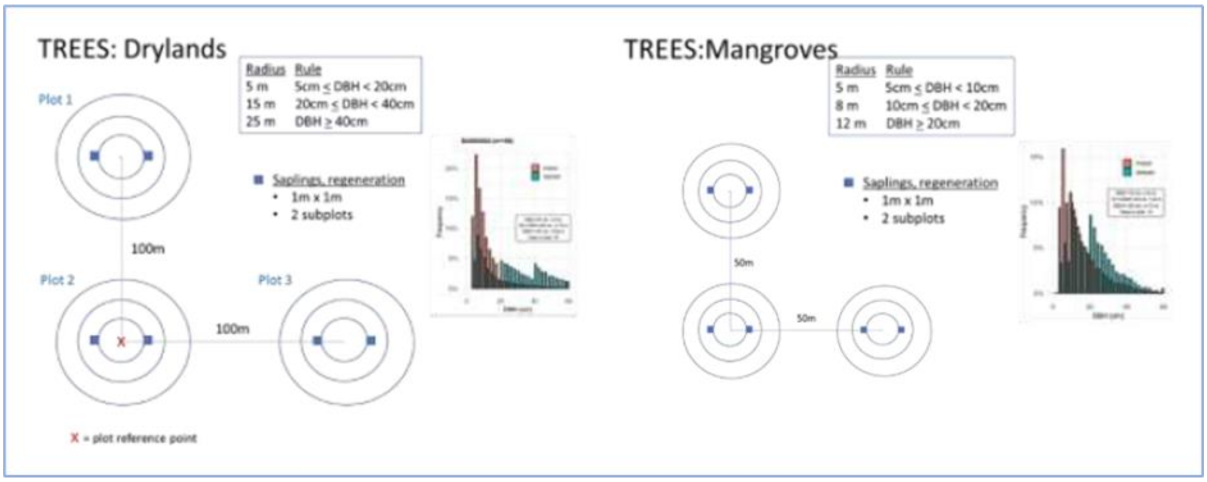


Figure 4*. The cluster-plot design for dry land and mangrove forests (Vesa & Tokola, 2023)*

A challege in determining the cluster-plot design for TOF was that there were no TOF inventory data in the existing NFI database. Fortunately, there was forest inventory dataset from BPKH-XI & MFP (2009) who conducted community forests inventory in Java and Madura in 2009. The dataset contained tree biomass measurements from 164 circular plots, in which each plot had a radius of 16.93 m or a size of 0.09 ha. These data were then analyzed as follows (adapted from Fehrmann et al., 2017):

1) Combined all sample plot data to create a 2-cm diameter class distribution, and then generated an overall stand structure of the community forests (CF).
2) Created a graph of cumulative values of stand attributes (i.e., basal area and biomass).
3) Classified the cumulative stand attribute values into three classes (i.e., <30%, 31–60%, and 61–100%) to determine diameter thresholds of three nested fixed-area subplots,

which would provide fairly balanced contributions of small, medium, and large trees when estimating stand attributes.

4) Calculated the size (A_s, m^2) and radius (R_s, m) of each nested fixed-area subplot by specifying a desired number of sample trees (T_d) and the number of trees per hectare of interest (N_i) within each diameter threshold using the following equation (Fehrmann et al., 2017):

$$A_s = T_d.(10000/N_i) \quad (1)$$

$$R_s = \sqrt{A_s/3.14} \quad (2)$$

Using that approach and the community forest inventory data of BPKH-XI & MFP (2009), this study found that the stand structure of community forests in Java and Madura followed a negative exponential distribution, in which the number of smaller trees was higher than that of bigger trees (**Figure 5a**). In average, the community forests had stand diameter of 19±8 cm, stand height of 11±3 m, and stand density of 235±152 trees/ha. These figures confirmed that nested fixed-area plots would be more efficient than single plots, because the community forests were dominated by smaller trees that provided small contributions to stand basal area and biomass. The fairly balanced cummulative percentages of the stand basal area and biomass were achieved at the diameter of 22.5 cm and 34.5 cm (**Figure 5b**), meaning that the nested fixed-area plots of CF may consist of three subplots with the diameter thresholds of <20 cm (for small trees), 21–25 cm (for medium trees), and >35 cm (for large trees). The CF inventory data showed that the number of trees per hectare (N_i) with DBH <20 cm was 146 trees, the N_i with 20≤DBH≤35 was 70 trees, and the N_i with DBH>35 was 19 trees. To facilitate an efficient measurement of a CF's cluster-plot, it was decided to measure a total of 13 trees per cluster-plot, consisting of 4 small trees, 5 medium trees, and 4 large trees. By using these numbers and Equation (1) and (2), this study came up with the plot area of 274.1 m^2 (with a radius of 9.3 m) for the small size nested subplot (DBH <20 cm), 715.8 m^2 (with a radius of 15.1 m) for the medium size nested subplot (20≤ DBH <35 cm), and 2131.4 m^2 (with a radius of 26.1 m) for the large size of nested subplot (DBH ≥35 cm).

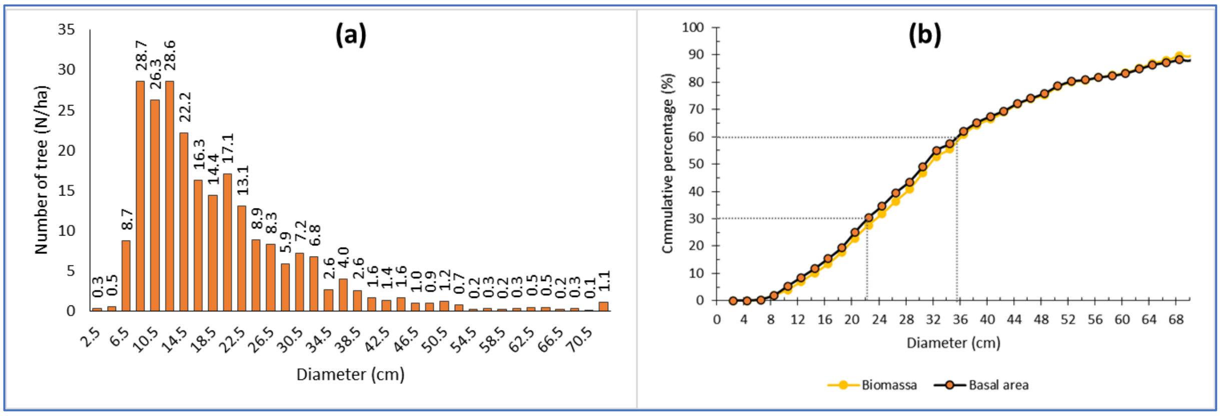
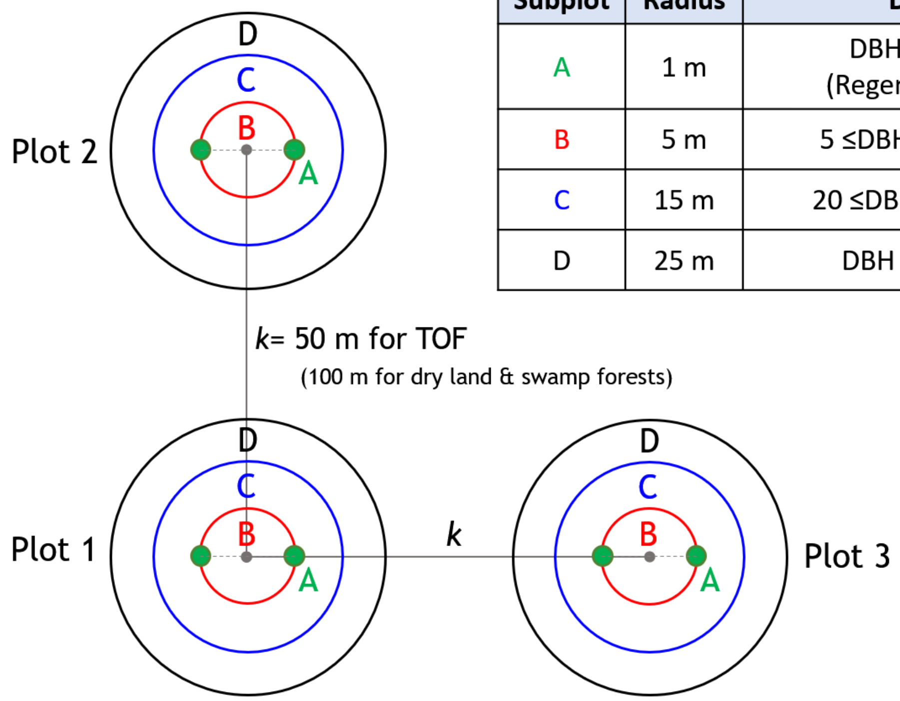


***Figure 5**. Stand structure (a) and cumulative percentage (%) of the stand basal area and biomassa (b) of the community forests in Java-Madura*

The tree diameter and radius of the three nested subplots of this study were slightly different than those proposed by Vesa & Tokola (2023) who suggested the three nested subplots with a radius of 5 m for small trees with 5≤ DBH <20 cm, a radius of 15 m for medium trees with 20≤ DBH <35 cm, and a radius of 25 m for large trees with DBH ≥35 cm. This discrepancy was mainly due to the stand structures of CF were differ than those of dry land forests. However, to maintain a consistency in conducting NFI in various land cover types (except in mangrove forests), the diameter and radius of the three nested subplots for community forests and other TOFs were then alligned with those for dry land forests. Therefore, the cluster-plot design of TOF is same as that of dry land forest in terms of the tree diameter and subplot radius thresholds, but the distances between the subplots of TOF are shorter (i.e., 50 m) than those of dry land forests (i.e., 100 m) by considering that TOF areas are commonly smaller than dry land forest areas (**Figure 6**).



Subplot	Radius	DBH
A	1 m	DBH <5 cm (Regeneration)
B	5 m	5 ≤DBH < 20 cm
C	15 m	20 ≤DBH < 40 cm
D	25 m	DBH ≥40 cm

***Figure 6**. The cluster-plot design for TOF*

4. NUMBER OF SAMPLES FOR TOF

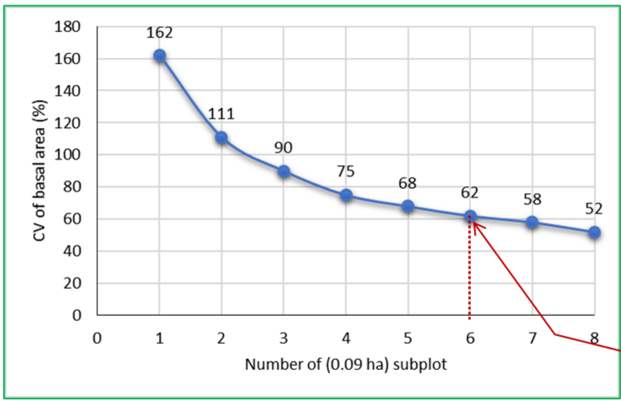
A cluster-plot serves as a sampling unit for measuring TOF attributes (e.g., stand volume and biomass) in a certain location. This sampling unit must be established in several locations to capture the variability of TOF attributes. Therefore, another essential NFI component is the number of samples (i.e., number of cluster-plots) required for conducting TOF inventory. The minimum number of samples is depend on the variability of stand attributes (e.g., basal area and biomass), in which TOF with high variability of stand attributes would require high number of samples, and vice versa. Statistically, the minimum number of samples is calculated using the Cochran (1977) formula:

$$n_0 = \left(\frac{t_{\alpha/2,n-1}.CV}{SE}\right)^2 \qquad (3)$$

where: n_0 is number of samples, *CV* is variation coefficient (%) of a stand attribute (i.e., stand basal area), and *SE* is allowable sampling error (i.e., estimation precision).

Commonly, the CV depends on stand variability and is affected by plot size, in which smaller plots generate higher CV, and vice-versa. It is necessary, therefore, to simulate various plot sizes when determining the number of samples for TOF inventory. By using the 164 plot data of BPKH-XI & MFP (2009), this study simulated 1000 times random samples without replacement, consisting of 1–8 plots to form a 'big-plot' with different sizes by ignoring the fact that those plots were separated in the field. This approach was used because there was no real big-plot TOF data like the 1 ha PSP of dry land forests. For each simulated big-plot, its CV was calculated based on mean and standard deviation of basal area. These CVs were then used in the Cochran (1977) formula (Eq. 3) to determine the minimum number of samples for each simulated big-plot at certain SE (5%, 10%, 15%, and 20%).

This study showed that the CV of TOF basal area decreased from 162% to 52%, depending on the size of simulated big-plots, in which the larger the simulated big-plot size the lower the CV (**Figure 7**). The CV of basal area sharply decreased until 62% and then relatively stable, confirming that the use of the big-plot size of 0.54 ha (i.e., 6 subplots of 0.09 ha each) would be sufficient for TOF inventory. The big-plot plot size of 0.54 ha is similar to a cluster-plot size consists of 3 subplots with each subplot radius of 25 m as discussed in Chapter 3. Based on the 62% CV, the number of samples for TOF inventory was 591 cluster-plots for 5% SE , 148 cluster-plots for 10% SE, 66% cluster-plots for 15% SE, or 37 cluster-plots for 20% SE (**Figure 7**). This study confirmed that the higher the precision target, the higher the number of samples required for TOF inventory. The final number of samples for TOF inventory could be decided by IPSDH by considering available resource for NFI. This study, however, suggests that the minimum number of samples for TOF inventory is 66 cluster-plots, which could be rounded to 70 cluster-plots to provide some allowances for inaccessible TOF areas. This number is applicable either for TOF in Java island or other islands, because there was no TOF inventory data available for calculating specific number of samples for the other islands. Therefore, the total number of samples for TOF in the seven islands of Indonesia is 490 cluster-plots.



Sub-plot	Area (ha)	Basal area (m^2/ha)			Number of samples (n)			
		Mean	Stdev	CV (%)	5%	10%	15%	20%
1	0.09	9.44	15.28	162	4033	1008	448	252
2	0.18	9.07	10.08	111	1893	473	210	118
3	0.27	8.64	7.79	90	1245	311	138	78
4	0.36	8.89	6.71	75	864	216	96	54
5	0.45	8.87	6.05	68	711	178	79	44
6	**0.54**	**8.55**	**5.31**	**62**	**591**	**148**	**66**	**37**
7	0.63	9.02	5.20	58	517	129	57	32
8	0.72	8.59	4.43	52	416	104	46	26

Similar to a cluster-plot consists of
3 subplots with each subplot radius of 25 m

***Figure 7**. The CV and number of samples for each subplot size at various sampling errors*

5. TESTING THE TOF'S SAMPLING DESIGN

To ensure the applicability of the TOF's cluster-plot design (Chapter 3), we (including the IPSDH and FAO staff) conducted two pilot testings in West Kalimantan and West Java. These pilot testing was also aimed at testing the applicability of the new NFI Technical Guidelines (called *Petunjuk Teknis (JUKNIS) IHN*), which was separated developed from this document, that covers field measurement procedures at an NFI cluster-plot not only for TOFs but also for dry land forests, swamp forests, and mangrove forests.

5.1. TOF's Pilot Testing in West Kalimantan

The TOF's pilot testing was conducted on 9 June 2023 at Sungai Bemban Village, Kubu Subdistrict, Kubu Raya Regency, West Kalimantan Province. In this village, the common land uses of TOFs were community forests in the form of mixed garden (agroforestry) planted with *pinang* (betel nut), *kelapa* (coconut), *sawit* (palm oil), and *durian*. In average, each household owns 1–2 hectares of TOF lands. We observed that an NFI cluster-plot might cross more than 1 garden, so that permit to access community lands is a must for implementing the new NFI in TOFs.

The field measurement of 1 cluster-plot (**Figure 8**), consisting of 3 plots (Plot 1, Plot 2, and Plot 3), in this village was conducted by a survey team consisting of 6 people. The Plot 1 contained 17 sample trees, 4 regeneration species, 250 grams of understorey fresh-weight, 540 grams of litter fresh-weight, 1 piece of deadwood (with diameter of 30 cm), and some palms (coconuts). The Plot 2 contained 4 sample trees, 1 regeneration species, 776 grams of understory fresh-weight, and some palms (coconuts and betel nuts). The Plot 3 contained 6 sample trees, 5 regeneration species, 160 grams of understorey fresh-weight, 950 grams of litter fresh-weight, 1 piece of deadwood (with diameter of 40 cm) and some palms (coconuts). The survey team was able to measure the Plot 1 for 2 hours, the Plot 2 for 30 minutes, and the Plot 3 for 1 hour. This means that the proposed cluster-plot design for TOF (as discussed in Chapter 3) provided time efficiency for the field measurement of a TOF cluster-plot.

***Figure 8**. The cluster-plot measurement of a TOF in West Kalimantan*

Based on the pilot testing in West Kalimantan, we got the following findings that were relevant for improving the new NFI design:

a). The land cover map for TOF was not accurate, in which mixed dry agriculture (in the field) was classified as an estate crop (in the map) and some parts of the secondary dry land forest was classified as a shrub. This findings suggested that for the next NFI, the results of cluster-plot measurements can be used to improve an land cover map.

b). The center plots of a cluster must be marked in the field. There is a need to add GPS coordinates for each plot to help a survey team in finding the center plot, and also to add 2 witness points to help a survey team in relocating the plots in the next cluster-plot measurements.

c). Plot level measurement should be ordered according to subplot size: A–B–C–D. After measuring regeneration, a survey team continues to measure understory, litter, deadwood, rattan/bamboo/palm, and then trees. The deadwood subplot should be extended into 4 crossed-lines (each of 5 m length). The understory and litter subplots should be located at a distance of 6 m from the plot center to avoid regeneration distructions.

d). The survey team confirmed that Vertex was very useful and easy to use for trees measurement using the new cluster-plot design. It was more efficient to hold a Vertex at the center plot while its transponder moved from one tree to another. The survey team suggested that an efficient work-flow in measuring a tree was to first measure DBH and then measure distance and azimuth to a tree.

e). The survey team suggested to reformulate tree height measuremet whether should be based on DBH classes or trees interval (e.g., 1, 5, 11, etc), because both approaches have their own pros and cons in the field. They also suggested that no need to measure height of all palms within a plot, instead only some sample palms. It was also necessary to determine a maximum number of sample trees and palms to be measured in a plot, because measuring all tree heights would be time consuming and prone to errors. In a later discussion, however, the survey team and IPSDH staff agreed to use the DBH class approach to measure 6 sample trees in each plot.

f). The Collect Mobile (CM) application should be improved to add validation rules for checking "IN/OUT" trees in each subplot (B, C, and D). In addition, the tree species database should be grouped according to vegetation group (i.e., tree, palm, etc.) and region group (i.e., island or province). The CM also needs some improvements on its user interface to facilitate an easy recording that follows the field measurements work-flow.

These pilot testing findings were then taken into account when revising the new NFI Technical Guidelines and the Collect Mobile application.

5.2. TOF's Pilot Testing in West Java

To further test the applicability of the TOF's cluster-plot design, we conducted second TOF's pilot testing at Cariu Subdistrict, Bogor Regency, West Java Province on 21–23

August 2023. We considered that this pilot testing was necessary because TOFs in Java differ than TOFs in West Kalimantan and other islands.

An essential step in conducting the TOF's pilot testing was coordination with local authorities, i.e., Branch Office of West Java's Forestry Agency (*Kantor Cabang Dinas Kehutanan Jawa Barat*) and Karyamekar Village. The coordination with the Branch Office of West Java's Forestry Agency aimed to ask two forestry staff as survey team members. These two forestry staff guided us to further coordinate with the head of Karyamekar Village, who then gave us a permission to access TOFs in his village. This coordination step is a must in implementing the new NFI design, because TOF areas beyond the authority of the Ministry of Environment and Forestry (MoEF).

The pilot testing was carried out by two survey teams in four TOF locations (**Figure 9**). Team 1 measured TOF at a monoculture community forest (i.e., *sengon* stand) and TOF at a mixed community forest. Team 2 measured TOF at a mixed community forest and TOF at a monoculture community forest (i.e., teak stand). Our field observations confirmed that stand conditions of the TOFs varied from one site to another. For example, the monoculture *sengon* (*Paraserianthes falcataria*) stands had lower stand density (with 5–18 sample trees per plot) than the monoculture teak stands (with 37–41 sample trees per plot). The TOF at mixed community forests had various trees species and DBH sizes, such as *sengon* (*Paraserianthes falcataria*), *jengkol* (*Archidendron pauciflorum*), *durian* (*Durio zibethinus*), and bamboo. Depending on the TOF conditions, the survey teams were able to measure one plot within 1–2 hours, so that a TOF cluster-plot could be measured within 3–5 hours. This finding similar to that of the previous pilot testing in West Kalimantan, which confirmed that the proposed cluster-plot design provided a working time efficiency in which field measurement of a TOF cluster-plot could be finished within one day.

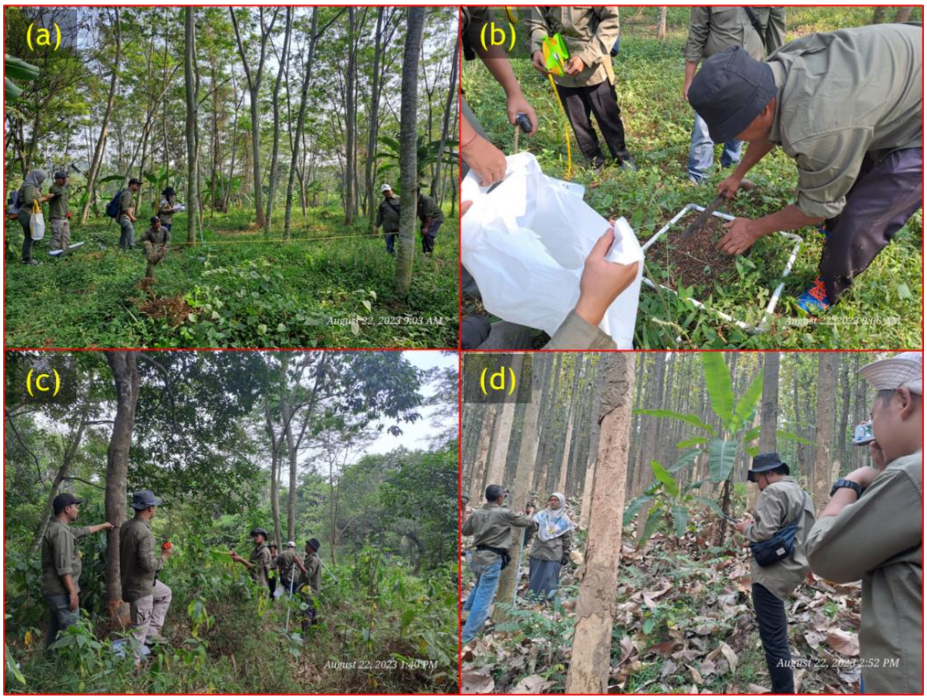


Figure 9*. The cluster-plot measurement of TOFs in West Java: (a) monoculture sengon stand, (b) understorey measurement, (c) mixed stand, and (d) monoculture teak stand*

In summary, the second TOF's pilot testing confirmed that the new NFI design could be well implemented in TOF areas. The new cluster-plot design provided some flexibilities in the field, in which the survey teams did not necessary to establish the largest subplot with 25 m radius (i.e., the subplot D) when TOF stands were dominated by small and medium trees (with DBH <40 cm), such as in the *sengon* and teak stands. More importantly, the two staff of West Java's Forestry Agency informed that the provincial government has annual budget for TOF inventory. They expected that the new NFI design could be adapted to improve their TOF inventory method, which is so far mainly based on remote sensing analysis without detailed field measurements. They also expected that the MoEF would provide a training for implementing the new NFI design. This is a good news for implementing the new NFI system through collaborative works with other parties, such as provincial governments.

6. CONCLUDING REMARKS

To complement the new NFI design, this report formulated and proposed a sampling design for Trees Outside Forest (TOF) inventory. TOF is defined as "a land classified as pure dry agriculture, mixed dry agriculture, dry shrub, and wet shrub according to the Indonesian land cover system with minimum area of 0.25 ha with trees higher than 5 m and canopy cover more than 10%". TOF land inventory can be carried out using a cluster-plot, consisting of three plots with a distance of 50 m. Each plot consists of three nested subplots with a radius of 5 m for small trees with 5≤DBH<20 cm, a radius of 15 m for medium trees with 20≤DBH<35 cm, and a radius of 25 m for large trees with DBH≥35 cm. To achieve a sampling error of 15%, the recommended number of cluster-plots for TOF inventory is 70 cluster-plots for each island or a total of 490 cluster-plots for the seven islands of Indonesia. The TOF pilot testings, which were conducted in West Kalimantan and West Java, confirmed that the proposed cluster-plot design provided a working time efficiency, in which field measurement of a TOF cluster-plot could be finished within one day. Accordingly, the new NFI design would be more efficient than the existing NFI design.

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