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Regular Research Article

Contribution of Agroforestry Systems to Farmer Income in State Forest Areas: A Case Study of Parungpanjang, Indonesia

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Abstract: Agroforestry activities in Forest Areas with Special Purpose (FASP) have been implemented since 2000 in Parungpanjang, West Java, which was subsequently reinforced by the Decree of the Minister of Environment and Forestry concerning the Recognition and Protection of Forest Partnerships (Kulin KK) for the Harapan Sejahtera and Guna Bakti Forest Farmer Groups in 2019. This study investigates the contribution of agroforestry systems to farmer income using a household survey in the Parungpanjang Research Forest. The study aims to analyze: 1) the contribution of agroforestry to farmer income from a household structured income analysis; 2) factors of agroforestry that influence total farmer household income using multiple regression analysis. The results show that agroforestry systems contributed 15.8% to farmer household income. The highest agroforestry productivity occurs in the age group of 41-45 years with an average of managed land area of 0.65 hectares and average annual income of IDR 16,780,000 (USD 1,198.6)/farmer/year. The statistical model showed that agroforestry income does not have a significant influence on total farmer household income due to differences in the types of commercial crops, motivation, and skill, as well as age related to physical abilities. There are only two agroforestry factors, namely age and land area, that have a significant influence on total farmer income, whereby the direction of the age variable has a negative influence.

Keywords: Agroforestry systems; Household income; Research Forest; Social forestry

1. Introduction

In order to address the global challenges of climate change, food security, and rural poverty, changes in environmental management systems are required. In the forestry sector, agroforestry is increasingly recognized as a viable option for overcoming these challenges (Mutonyi & Fungo, 2011). Agroforestry is a system of natural resources management that integrates trees on farms and in the agricultural landscape to diversify and sustain production (Molla, 2019). Agroforestry is a cost-effective strategy for climate change mitigation (Baliton et al., 2017), that provides benefits on carbon sequestration and storage (Zomer et al., 2016; Feliciano et al., 2018), increases ecosystem services (Shin et al., 2020), simultaneously provides job opportunities (Borrella et al., 2015), and there is a positive relation between agroforestry and community (Humphries et al., 2012).

In practice, agroforestry is often described as a suitable system for the needs of community in their land use systems. Several studies of agroforestry systems in Indonesia have shown that it has brought about several positive impacts particularly because it increases productivity of forest land (Suryanto et al., 2013), improves soil quality (Mulyono et al., 2019), plays an important role in maintaining avian diversity (Withaningsih et al., 2020), brings economic benefits for local communities (Sudaryanto & Variasa, 2018; Kamaluddin et al., 2020), and promotes food security

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(Wulandari et al., 2014). However, agroforestry still faces challenges mainly with regard to the agriculture expansion caused by commercialization of timber (Kusters et al., 2008), poverty alleviation and farmer household welfare (Nuryati et al., 2019), community participation (Dwijanti et al., 2018), and lack of market and community access to finance opportunities (Suyadi et al., 2019).

To date, the Government of Indonesia has established 35 Forest Areas with Special Purpose (FASP) for research, education, training and religious purposes. FASPs are located in various regions with a total area of 37,569.05 hectares (Ratina, 2019), one of which is located in Parungpanjang, Bogor Regency, West Java. FASP Parungpanjang has applied agroforestry systems since 2016, which was subsequently received strengthened authority by forestry partnerships through the Social Forestry (SF) model since 2019. The SF provides access for Harapan Sejahtera and Guna Bakti Forest Farmer Groups (FFG) to manage the forest through an agrosilviculture model for 35 years. It is aimed at increasing the productivity of research on forest land, such as the quality of shade tree plants, the productivity of intercropping plants, soil fertility, and on the improvement of local community welfare (Desmiwati et al, 2018).

As a research forest, various studies on FASP Parungpanjang have already been carried out, particularly focusing on the technical aspects of silvicutural forest plants. Studies on the social economic aspects of the FASP, on the other hand, are still very limited and mostly conductive through qualitative research such as research on community attitudes and behavior (Surati, 2014), perceptions and participation levels of smallholder farmers (Desmiwati, 2016), social capital of smallholder farmers (Desmiwati et al, 2018), agroforestry patterns and livelihood strategies of smallholder farmers (Desmiwati & Nugraheni, 2018) and economic perceptions of smallholder farmers (Hendarto et al, 2020), and roles and voice of farmers in the “special purpose” forest area: strengthening gender responsive policy (Dewi et al, 2020).

Referring to the aims of the agroforestry system and SF implementation in FASP Parungpanjang, this study aims to fill the gap on socio-economic aspects of FASP to complement the baseline data for impact measurement. The objectives of this study are as follows: first, to calculate the contribution of agroforestry to farmer income, and second, to analyze agroforestry factors that influence farmer income. The main research question of the study is: does agroforestry has a significant contribution to the rural economy?

2. Methods

2.1. Study Area

This study was conducted in the Parungpanjang FASP ($106^{0}31'06"$E, $06^{0}22'58,9"$S) managed by the Forest Tree Seed Technology Research and Development Center (FTSTRDC), of the Ministry of Environment and Forestry (MoEF). The area directly borders four villages namely Jagabaya and Gintung Cileujet Village, Parungpanjang District, and Tapos and Batok Village, Tenjo District, Bogor Regency, West Java (Figure 1). Initially, the Parungpanjang FASP was located in the *Perum Perhutani* production forest area as stated in the Loan and Use Agreement[1]. Subsequently, the designation was changed to a FASP in accordance with the Decree of the Minister of Environment and Forestry in 2019[2]. Furthermore, on 27 August 2019, the Parungpanjang FASP became the first Social Forestry model implemented by the MoEF out of a total of 35 FASPs in Indonesia. The Social Forestry permit (35 years) is stipulated through the Decree of the Minister of Environment and Forestry Number SK. 7087/Menlhk-PSKL/PKPS/PSL.0/8/2019 concerning the Recognition and Protection of the Forest

[1] The Loan and Use Agreement No.08/044-3/III/1996 and 796/VIII-BTP/12/1996

[2] The Decree of the Minister of Environment and Forestry No. SK.169/Menlhk/Setjen/PLA.0/2/2019 dated February 25, 2019 with an area of ± 100 Ha.

Partnership (Kulin KK) of the Harapan Sejahtera Forest Farmer Group (FFG) covering an area of 10.7 hectares, which includes 19 members.

On the same date, MoEF also issued the Decree of the Minister of Environment and Forestry Number SK.7089/Menlhk-PSKL/PKPS/PSL.0/8/2019 concerning the Recognition and Protection of the Forest Partnership (Kulin KK) of Guna Bakti FFG covering an area of 8.75 hectares with 21 members.

This research provides a baseline of socio-economic data as a parameter to measure forest management using the Forestry Partnership scheme (Kulin KK).

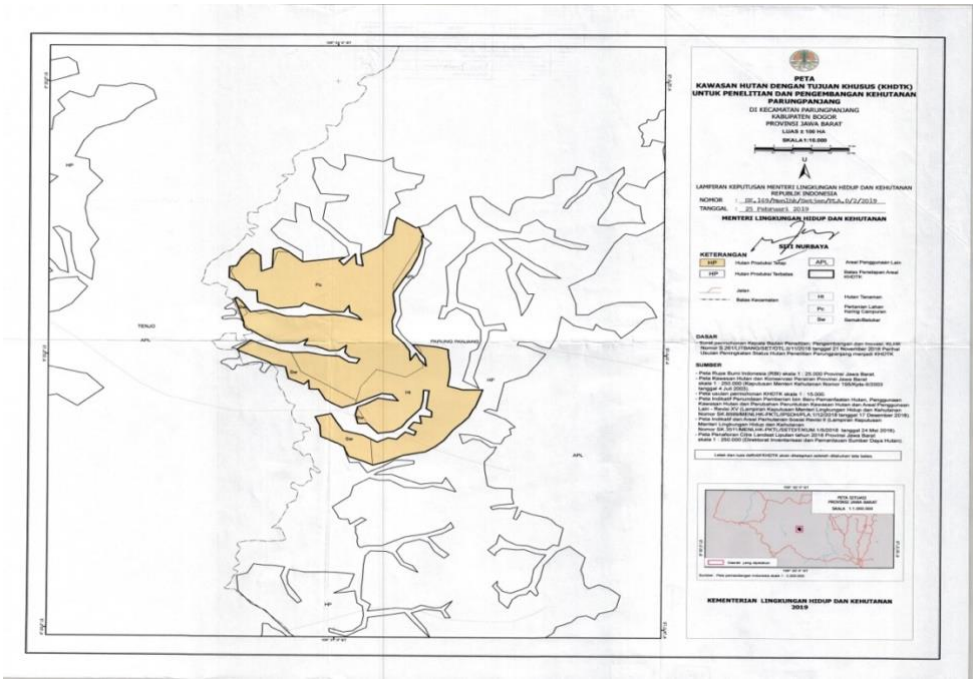

Figure 1. Location of field study

2.2. Data Collection

The data was collected from September until October 2019 using a household census survey with a total of 52 respondents consisting of farmer households in the Tapos Village (N=31) and Jagabaya Village (N=21), Bogor Regency, West Java. The household questionnaires drew from the National Survey on Socio-economic Issues questionnaire developed by the Indonesia Bureau of Statistics (BPS), and introduced several modifications. The census method and questionnaire was used to explore the demographic characteristics of the village and the respondents, as well as collecting baseline data for further in-depth surveys (Malleson et al., 2008). Meanwhile, observations and in-depth interviews were conducted to obtain detailed farmer household socioeconomic dynamics and demographic information.

Furthermore, two focus group discussions (FGD) were conducted in each village with 25 farmer participants in Tapos Village and 21 participants in Jagabaya Village. The FGDs verified and deepened information related to agroforestry patterns and types of commercial crops that had been developed, as well as information on seasonal calendars and agroforestry income referring to each type of commercial crops cultivated.

2.3. Analysis

2.3.1 Contribution of agroforestry income to total farmer household income

Total farmer income was analyzed by calculating all activities that generate both cash and in-kind income. In-kind income is calculated by summing up all the value of products consumed directly by farmer households (Faße & Grote, 2013; Angelsen et al., 2014). The formula used is as follows:

Total farmers income=Σ (*On-farm Income + Off-farm income+Non-farm Income*) (1)

In this study, on-farm income activities included agroforestry and livestock, and off-farm income included work as daily laborers. Non-farm income activities included stalls and hawkers, bike mechanics, craftmans (*Boboko*/bamboo craft) and others (service activities and transfers). The agroforestry contribution was analyzed by calculating agroforestry income to the total farmers income in a year. The formula used is as follows:

$$\%\ \text{Igri} = \left(\frac{\text{I gr}}{\text{I tot}}\right) \text{x } 100\ \% \quad (2)$$

Where, % Igri = Contribution of agroforestry income to the total farmers income (% in a year); Igr = total income from agroforestry activities (IDR/year); Itot = Total farmers income (IDR/year).

2.3.2 Factors of agroforestry system that influence farmer household income

Multiple linear regression analysis was carried out to determine agroforestry factors that have a significant influence on farmer income. The equation model (Sarstedt & Mooi, 2014) is as follows:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + e \quad (3)$$

Where, Y = Farmers income (IDR/year); α = constant; β_1- β_8 = regression coefficient; X_1 = Agroforestry income (IDR/year); X_2 = Age (years); X_3 = Education (years); X_4 = Family size (person); X_5 = Land area (hectare); *e* = error. The t test is conducted by comparing the p-value (Sig.) of the regression test results with the degree of error used in this model i.e. 10% or α = 0.1. The references of variables can be seen in Table 1 below.

Table 1. References of Variables

No	Variable	Source of References
1.	Age	Suherdi et al., 2014
2	Education	Marschke & Berkes, 2005; Parhusip et al., 2019
3	Family size	Rahman et al., 2017
4	Land area	Nyaga et al., 2015, Van Chu et al., 2019

Due to data limitations (52 farming households), this research conducted several tests on the regression model to mitigate statistical issues that might arise and ensure the robustness of the model i.e Normality, Linearity, Heteroscedasticity, Multicollinearity and Regression Spesification Error Test (RESET).

3. Results and Discussions

3.1 Agroforestry practice

The main tree species that dominate the forest vegetation structure of the Parungpanjang FASP are mahogany (*Swietenia macrophylla*), acacia (*Acacia mangium*), nyamplung (*Calophyllum inophilum*), gempol (*Nauclea orientalis i Linn*), merbau (*Intsia bijuga*), kepuh (*Sterculia foetida*), mindi (*Melia azedarach*), tisuk (*Hibiscus sp*) and white jabon (*Anthocephalus cadamba*). Intercropped plants were dominted by galangal *(Lenguas galangal*), chinese potato (*Coleus*

tuberosus) and peanut (*Arachis hypogaea*). Tree plantations in this area are research objects of FTSTRDC.

Farmer Groups members in Tapos Village and Jagabaya Village have practiced agro-silviculture by applying alley-cropping techniques in a simple pattern with a limited number of intercropping cultivated varieties. Alley-cropping techniques allow farmers to plant agricultural crops in alleys in between woody plants (Shin et al., 2020). The main inter-cropped plant species was galangal (*Lenguas galanga*) with other secondary and additional intercropped plants (Table 2).

Table 2. Agroforestry patterns adopted by farmers in FASP Parungpanjang.

Agroforestry Patterns	Intercropped plants		
	Primary	Secondary	Additional
Type 1	Galangal (*Lenguas galanga*)	Pongamia (*Pongamia pinnata*)	Cassava (*Manihot utilissima*) Banana (*Musa* sp.)
Type 2	Galangal (*Lenguas galanga*)	Largeleaf rosemallow (*Hibiscus macrophyllus*)	
Type 3	Galangal (*Lenguas galanga*)	Peanut (*Arachis hypogaea*)	
Type 4	Galangal (*Lenguas galanga*)	Chinese potato (*Coleus tuberosus*)	
Type 5	Galangal (*Lenguas galanga*)	Red Jabon (*Anthocephalus macrophyllus*)	
Type 6	Galangal (*Lenguas galanga*)	Cheesewood (*Nauclea orientalis*)	

Source: Primary data, 2019

3.2 Contribution of agroforestry to farmer income

Table 3. shows the education level of the respondents in both villages. The majority of the respondents graduated from elementary school (55.8%), while 36.6% did not graduate from elementary school, although most of them can read and write. Only 7.6%, or four respondents, had a higher education level than other respondents. According to age group, respondents over 45 years old amounted to 67.3%, while 13.4% of respondents were over 60 years old (Table 4).

The study found that the age of respondents ranged from 30–78 years. Table 4 shows that the age group of 41-45 years (9.6%) managed the largest part of agroforestry land area than other age groups, namely an average of 0.65 hectares. Out of the total land managed by farmers (22.9 hectares), the average area of managed land is 0.44 hectares per farmer.

Table 3. Education level of farmers

No	Education level	Frequency	Percentage
1	Did not graduate from Elementary School (< 6 years)	19	36.6
2	Elementary School - SD (6 years)	29	55.8
3	Junior High School – SMP (9 years)	2	3.8
4	Senior High School - SMA (12 years)	2	3.8
	Total	52	100

Source: Primary data, 2019; N=52

Table 4. Farmer composition based on age group

Age Group	Farmers Households		Total Land Area (Hectare)	Land Area per age group (hectare)
	N	Percentage		
30 - 35	4	7.7	1.25	0.31
36 - 40	8	15.4	2.90	0.36
41 - 45	5	9.6	3.25	0.65
46 - 50	15	28.9	7.00	0.47
51 - 55	6	11.5	3.00	0.50
56 - 60	7	13.5	3.25	0.46
61 - 65	3	5.7	1.00	0.33
> 65	4	7.7	1.25	0.31
Total	52	100	22.9	0.44

Source: Primary data, 2019

Table 5 shows that the contribution of agroforestry income to total farmer income was 15.8% with an average agroforestry income of IDR 3,829,519 (US$ 273.5) per farmer per year. The highest contribution to total farmer income was from working as daily laborers (33.7%), followed by income from stall/hawkers (28.9%). The lowest contribution to farmer income is from livestock (1.6%). Agroforestry is an alternative livelihood option where the main income of farmers are off-farm and non-farm activities. This is because farmer households are landless and are unable to develop agricultural activities. Furthermore, low education and poverty have caused them to seek out selected employment that relies more on physical abilities that do not require large capital, such as daily laborers and hawkers.

Table 5. Average farmer household income based on income sources per year (in IDR)

No	Source of Income	Total Income	Mean	SD	Income Shared (%)
1	On-farm				
	Agroforestry	199,135,000	3,829,519	6,255,682	15.8
	Livestock	20,800,000	400,000	1,670,505	1.6
2	Off-farm				
	Daily laborers	424,990,000	8,172,885	13,440,567	33.7
3	Non-farm				
	Stall/Hawkers	364,565,000	7,010,865	14,345,205	28.9
	Bike Mechanic	28,800,000	553,846	3,993,841	2.3
	Craft (Boboko)	42,386,500	815,125	2,328,566	3.4
	Others	180,080,000	3,463,076	6,646,217	14.3
	Total	1,260,756,500	24,245,316	17,743,668	100

Source: Primary Data, 2019 Total N= 52; US$ 1= IDR 14,000

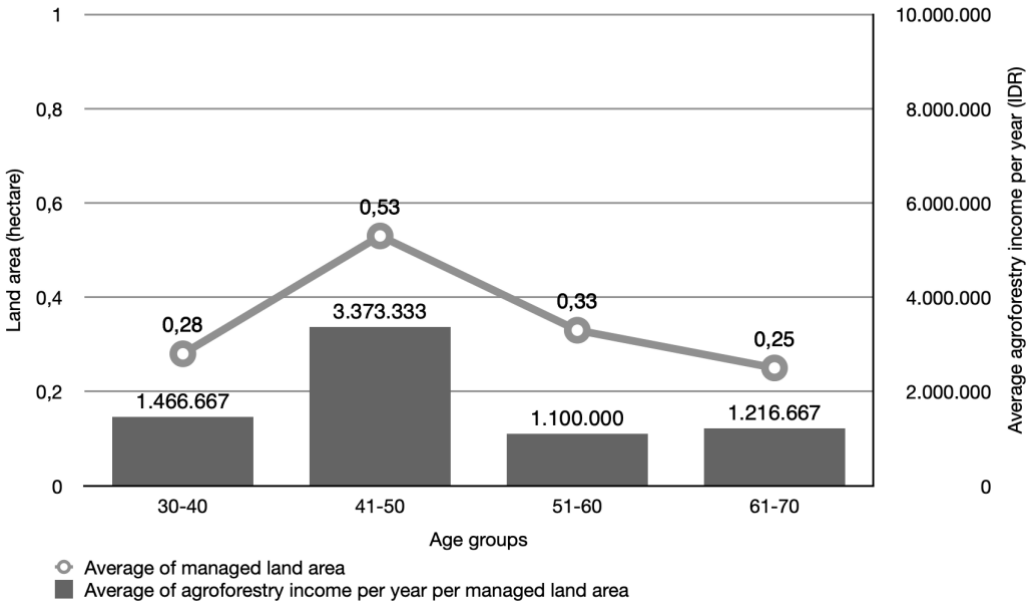

Figure 2. Distribution of farmer income based on land area and age group.

Figure 2 explains that the highest productivity of agroforestry occurs in farmers aged 41-45 years with an average land area of 0.65 hectares and an average income of IDR 16,780,000 (US$ 1,198.6) per year per farmer. In the age group 46-50 and above, agroforestry income tends to decrease along with the area of land being managed. The downward trend of farmer income from agroforestry was explained in Table 2 and shows that the majority of farmer groups members involved in agroforestry businesses are over 45 years (67.3%).

While the age group of 30-40 years manages land with an average area of 0.31-0.36 hectares, yet, the level of agroforestry income is still relatively low in this group compared to the same level of land in other older age groups (61-65 years). This is due to the fact that younger farmers are not as focused on agroforestry, as it is viewed as an additional livelihood that makes the land become unproductive. The younger farmers earn their main income from other livelihood options such as daily laborers and hawkers.

In the case of the Parungpanjang FASP, the contribution of agroforestry income to total farmer household income is 15.8%, with agroforestry income contribution in each farmer household described in Figure 2. This has been caused by the following 1) different types of intercropping planted, namely although the main intercropped plants (galangal) are relatively the same and provide a large share of income, yet other intercropped plants also contribute to increasing farmers income; 2) farmers motivation and skills, for farmers who regularly apply fertilizer and clean the land, the results are much better than plants that remain unmanaged after planting; 3) age also affects the physical ability to cultivate land. The majority of farmer groups members are already elderly and expressed that they are unable to cultivate larger areas land. These farmers feel that the land that has been cultivated is sufficient.

According to Brown et al. (2018), there are two important factors as a precondition for success in adopting an agroforestry system before making further interventions namely, successful mobilization and engagement of farmers and facilitating farmer capacity development and/or access to qualified tree/agriculture seeds. Several interventions are needed after the precondition phases have been met, include providing incentives, facilitating market networks, and institutional and policy change.

3.3 Factors of agroforestry system that influence on the farmers household income

The agroforestry system factors analyzed in this regression model are explained in Table 6. Of the five variables analyzed by t-test, there are two variables that have a significant influence on total farmer income, namely age and land area (Table 7), whereas education, family size, and agroforestry income variables do not have a significant influence on the total farmers household income.

Table 6. Explanation and summary statistics of variables

Variable	Explanation	Mean	Std. Deviation	N
Farmers Income (Y)	Total farmer income in IDR per year	24245317.31	17743668.217	52
Age (X_1)	Age in years	50.2885	10.55580	52
Education (X_2)	Education in years	4.6923	2.96739	52
Family Size (X_3)	The family member of household (person)	3.5000	1.83110	52
Agroforestry Income (X_4)	Household annual income from agroforestry in IDR	3817980.7692	6260676.86152	52
Land Area (X_5)	Land area in hectare	.4404	.29952	52

Source: Primary data, 2019.

Age (Sig. 0.007) has a negative influence direction, which means that as age increases, farmer income will decrease, due to the contribution of agroforestry income also decreasing as farmers get older and the limited area of land that can be managed. Agroforestry activities require farmers who are in the productive age (18–50 years) due to intensive workload (Suherdi et al., 2014; Suyadi et al., 2019). In the Parungpanjang FASP context, farmer physical ability to manage land will determine the productivity and income received by the farmers. This phenomenon is verified by the findings listed in Figure 2.

Table 7. Result of t-test

Model	Standardized Coefficients	t	Sig.	Collinearity Statistics	
	Beta			Tolerance	VIF
(Constant)		3.250	.002		
Age (X_1)	-.400	-2.814	**.007***	.816	1.226
Education (X_2)	-.051	-.364	.718	.827	1.209
Family Size (X_3)	-.049	-.369	.713	.926	1.080
Agroforestry Income (X_4)	.035	.251	.803	.849	1.178
Land Area (X_5)	.282	2.041	**.047***	.866	1.155

a. Dependent Variable: Y – Household Income; * sigficant at *p value* < 0.05

Land area (Sig. 0.047) of the agroforestry system has a significant influence on the total farmer income. This is consistent with Van Chu et al. (2019), which stated that farmers with larger forestry land area have more chance to increase their household income. In this case, significant agroforestry income is obtained from farmers aged 41-45 years with an average land area of 0.65 hectares. Land productivity is also closely related to farmer capacity and access to resources, as well as access to markets (Borrella et al., 2015; Brown et al., 2018).

4. Conclusion

Agroforestry practices in the Parungpanjang FASP have contributed to the income of farmer groups members, but the effects are still imbalanced. This is influenced by the types of plant cultivated, motivation and skills, and age relative to ability to manage land. Regarding the results of the regression analysis, there are two agroforestry factors that influence farmer income, namely age and land area.

In order to optimize the contribution of the agroforestry system to farmer income in the Parungpanjang FASP, it is necessary to increase land productivity by assessing profitable intercropped plant types in corresponding soil or land characteristics and minimum requirements of physical treatments. Furthermore, FTSTRDC need to strengthen the capacity of farmer groups members by facilitating technical capacity for training of good agricultural practices, including facilitating the business model and market network of agroforestry products.

Author Contributions: Conceptualization and design of the experiments were conducted by D., and K.A.H., who performed the experiments. D and T.O.V analyzed the data and wrote the paper. D, T.O.V, and K.A.H., are the main contributors of the paper, and the others are member contributors. All authors have read and agreed to the published version of the manuscript.

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