SOLAR DRYING SOLUTIONS

FOR CACAO AND COFFEE SMALLHOLDER FARMERS IN TABANAN, BALI

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ABOUT THE REPORT

Kopernik, with support from the Climate and Land Use Alliance (CLUA), together with smallholder farmers, conducted an experiment to find efficient methods to dry cacao and coffee beans in Tabanan, Bali. The report outlines the experiment process, and presents the findings from the use of a solar dryer to dry the two commodities. Recommended next steps are provided, which focus on increasing farmer capacity during the post-harvest process.

As a key component of the post-harvest process for cacao and coffee, drying is difficult for farmers, with unpredictable weather patterns presenting a particular challenge. This issue requires attention and is critical to address, as it affects farmer incomes if the drying process is unsuccessful, farmers will be unable to sell their product. As part of this initiative, we conducted an experiment to identify an effective drying solution by developing a low-cost solar dryer to help farmers to dry their commodities.

The results of the experiment can provide a useful reference for those who are active in the cacao and coffee sector, as well as development actors supporting smallholder cacao and coffee farmers.

EXECUTIVE SUMMARY

Smallholders in Tabanan face difficulties in drying cacao and coffee beans due to unpredictable weather patterns. A simple low-cost technology is required to protect the beans from rain and other contaminants. We conducted an experiment with a solar dryer, using the following process:

TECHNOLOGY DESIGN

- Design of the solar dryer.
- Use of locally available materials to develop the dryer.
- Build the dryer together with farmers.

DRYING

Two methods of drying:

Solar dryer

- Beans are placed inside the dryer.

Floor drying

- Beans are placed on a tarpaulin and dried on the ground. This is the typically used method by farmers.

DATA COLLECTION

- Collect data on dryer performance, effectiveness and efficiency.
- Measure the quality of the dried beans.

DISSEMINATION

- Conduct a dissemination event to share findings and lessons from the experiment with farmers, local government officials and business actors.

RESULT The solar dryer protected the beans from rain, and reduced farmers' active work time.

NEXT STEPS The dissemination event resulted in interest from the local government to replicate the technology with funding from the village fund mechanism (dana desa). Kopernik will continue to provide support by providing guidance on the construction and use of the dryer.

PROJECT LOCATION:

Sanda village, Tabanan, Bali

PERIOD:

Aug – Oct 2020

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COMMODITY OVERVIEW

This experiment focused on cacao and coffee, which are two of the top commodities produced in tabanan.

CACAO

Yield	833 tons
Land	4,532 ha
Smallholder farmers	23,375 farmers
Varieties	Sulawesi 1, Sulawesi 2 & Local/Lindak

Indonesia is one of the world's top cacao producers, and in 2019 the country exported 380,829 tons of cacao (Bureau of Statistics, 2019). Smallholder farmers are critical to the steady production of the commodity, and own and manage 99.3% of cacao plantations in the country.

Bali has 55,903 cacao farmers placing the province amongst the top 20 producers in Indonesia. Tabanan regency, considered to be Bali's center for agricultural produce, has 4,532 ha of cacao plantations, owned by smallholder farmers.

COFFEE

Yield	228 tons
Land	9,585 ha
Smallholder farmers	17,387 farmers
Varieties	Robusta

Coffee is one of Indonesia's largest export commodities. In 2019, Indonesia exported 279,961 tons of coffee with an economic value of US$815 million (Bureau of Statistics, 2019), and 96.6% of coffee plantations are owned by smallholder farmers.

Bali is the tenth largest coffee producing region in Indonesia and has 71,857 coffee smallholder farmers. Tabanan regency, which is the largest coffee producing area in the province has approximately 9,585 ha of coffee plantations.

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COMMODITY OVERVIEW

Farmers' current practice of drying the beans openly on the ground puts the commodity at risk of spoilage due to rain and other contaminants. We introduced a solar dryer to enable farmers to dry beans efficiently whilst protecting their beans.

PROBLEM

- The current drying method exposes beans to rain and other contamination.
- Significant time and effort is required to administer the open floor drying process.
- No fermentation of cacao beans being conducted prior to drying.
- Beans are often not dried and sold wet, at a lower price.

SOLUTION

- A solar dryer that enables efficient drying, and protects beans from rain and other contaminants.
- A set of fermentation boxes for cacao.

EXPERIMENT

- Build the solar dryer together with farmers.
- Ferment cacao beans using fermentation boxes.
- Dry beans in the solar dryer.
- Compare bean quality of those dried in the solar dryer, with beans dried using open floor drying.

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EXPERIMENT DESIGN

Together with the farmers, we sorted and fermented cacao beans before placing them in the solar dryer to reach the moisture level required by the market of 7.5%. For coffee beans, no fermentation was required and the beans were directly placed in the solar dryer until they reached a moisture level of 12.5%.

SORTING

Beans are sorted to make sure all beans that don't meet market requirements are removed.

FERMENTATION (CACAO)

Cacao beans are placed in a set of three-tiered wooden boxes and fermented for up to six days, until till they reach a temperature of 44-48°C.

DRYING

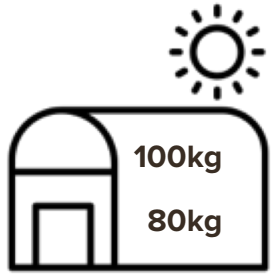
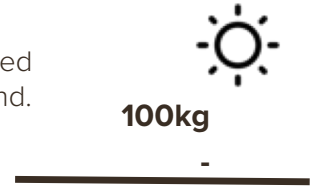
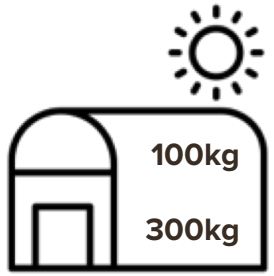
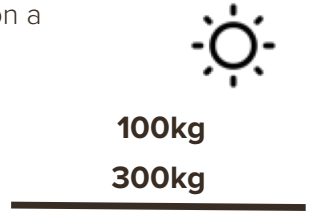
Beans are dried in the solar dryer to reduce moisture content required by the market; 7.5% for cacao and 12.5% for coffee.

DRIED BEANS

Dried beans are ready to be sold.

METHODOLOGY

Our hypothesis was that the solar dryer will dry the beans effectively and protect them from rain and other contaminants. We tested this hypothesis by comparing the beans dried in the solar dryer, with beans dried using the open floor drying method.

	TREATMENT GROUP Solar Dryer	CONTROL GROUP Floor Drying
FERMENTED • *Total weight of wet cacao: 200kg* • *Total weight of wet coffee cherries: 80kg*	Cacao: • Beans are fermented for 6 days (44-48°C). • Fermented beans are placed in the solar dryer. Coffee – honey process*: • Honey processed beans are placed in the solar dryer. 	Cacao: • Beans are fermented for 6 days (to reach 44-48°C). • Fermented beans are placed on a tarpaulin on the ground. Coffee – honey process: • Not applicable for honey processed beans. 
NON FERMENTED • *Total weight of wet cacao: 200kg* • *Total weight of wet coffee cherries: 600kg*	Cacao: • Sorted beans are placed in the solar dryer. Coffee – natural process: • Coffee cherries are placed in the solar dryer. 	Cacao: • Sorted beans are placed on a tarpaulin on the ground. Coffee – natural process: • Coffee cherries are placed on a tarpaulin on the ground. 

INDICATORS MEASURED

Dryer performance

Time to dry

Total number of days taken to reduce bean moisture content (cacao 7.5%; coffee 12.5%).

Effort required by farmers

Total number of hours spent per day for farmers to administer the drying process.

Temperature and humidity

Daily indoor/outdoor temperature and humidity during the drying process.

Bean quality

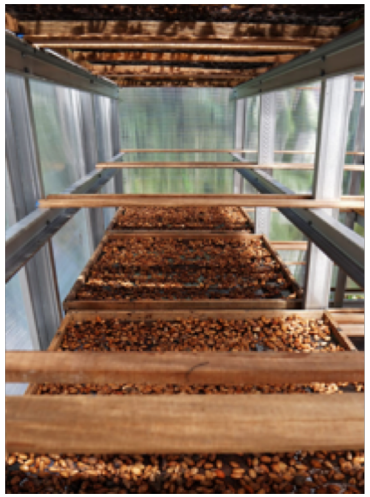
Quality assessment

Variables include moisture level, color, mold, slaty and bean count.

**Honey process refers to red beans that are first sorted using a water floating method and then opened with a hulling machine before being placed in the solar dryer. They are not 'technically' fermented.*

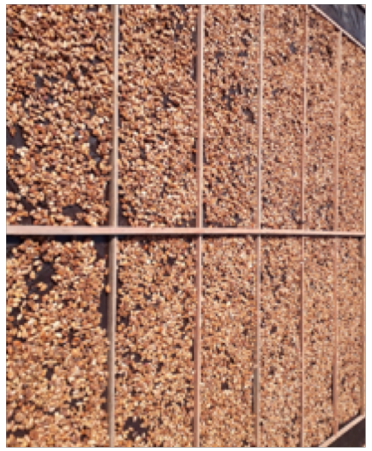
METHODOLOGY

Upon completion of the drying process, we randomized the beans from each group for sampling purposes. Bean samples from each group were sent to experts, middlemen and artisan buyers to assess the quality of the beans.



TREATMENT GROUP

Solar Dryer
The beans are placed on numbered racks inside the solar dryer.



CONTROL GROUP

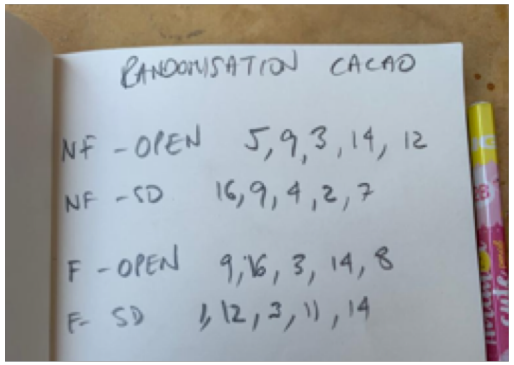
Floor Drying
Beans are placed on a tarpaulin divided into 16 numbered sections.

Randomized sampling

The number of each rack/section are written down on individual pieces of paper.

The pieces of paper with numbers are placed into a hat, and five numbers are selected from the hat to obtain the five samples that will be selected.

The numbers selected reflect the rack/section numbers which will be used for quality testing.



The randomly selected samples from each group are taken to experts and buyers for quality testing.

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SOLAR DRYING SOLUTION

The solar dryer was designed with several innovative features to enable effective and efficient drying of the cacao and coffee beans.

1 Gravel was used for the base of the dryer to retain heat.

2 Two exhaust fans were installed for maintaining good air circulation.

3 Plastic netting was used for the body of the drying racks to avoid rust.

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SOLAR DRYING SOLUTION

Farmers can build the low-cost solar dryer using locally available materials.

Specification

- Capacity: ± 300 kg
- Energy source: Heat from the sun
- Air circulation: Exhaust fans, ventilation holes on the lower and upper sections of the solar dryer

Materials

ITEM	SIZE	TOTAL
Polycarbonate	11.8 m x 2.1 m x 5 mm	2 rolls
Wood or light steel	5 cm x 10 cm x 400 cm	3 units
	5 cm x 5 cm x 400 cm	20 units
	3 cm x 5 cm x 400 cm	17 units
	2 cm x 5 cm x 400 cm	32 units
Wood or light steel	2 cm x 3 cm x 400 cm	94 units
Netting	100 m	1 roll
Iron plate	240 cm x 120 cm x 1.5 cm	3 units
Sand	1 m^3	1 m^3
Cement	50 kg	5 sacks
Gravel	1 m^3	2 m^3
Silicon Glue	300 ml	3 tubes
Exhaust fan	12 cm x 12 cm – 1.6 VA	2 units

Total cost : ± IDR 17.000.000

EXPERIMENT RESULTS CACAO

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CACAO

According to good agricultural practice guidelines, the post-harvest steps for cacao include sorting of beans, fermentation, and drying.

SORTING

- After harvesting, the cacao pods are cut laterally to extract the wet beans.
- High quality wet beans are characterized by the absence of insects or presence of sprouts.
- The sorting process is conducted at this stage by separating any defect beans and placental stalks.

FERMENTATION

- Wet cacao beans are placed inside a three-tiered fermentation box to develop fragrance and flavor.
- The fermentation process is conducted for six days; two days in the upper box, they are then moved to the middle box for two days, and finally the beans are moved to the bottom box for a further two days. The beans are then moved to the solar dryer.

DRYING

- The drying process reduces the moisture content of the beans. The required moisture content for cacao beans is between 5% - 7.5%.
- The drying time in the solar dryer typically takes between 4 – 7 days, depending on the weather condition and amount of beans placed on the drying racks.

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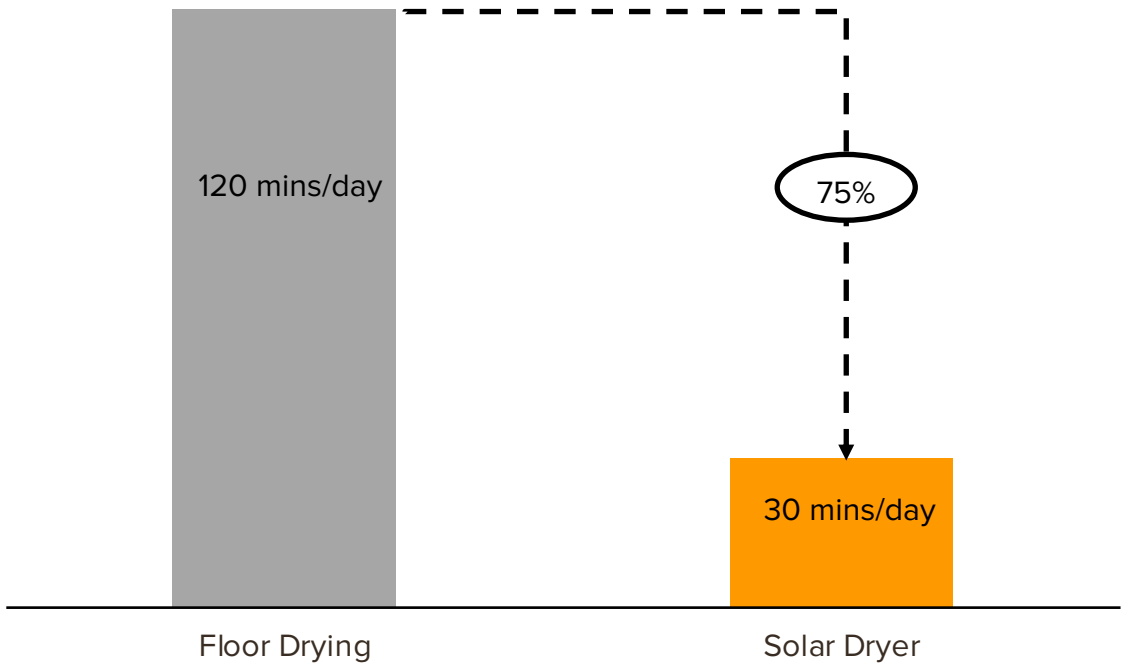
CACAO

The results of the experiment showed that the solar dryer reduced the time and effort required by farmers during the drying process by 75%. The beans in the solar dryer took three to five days to reach a moisture level of 7.5% or below.

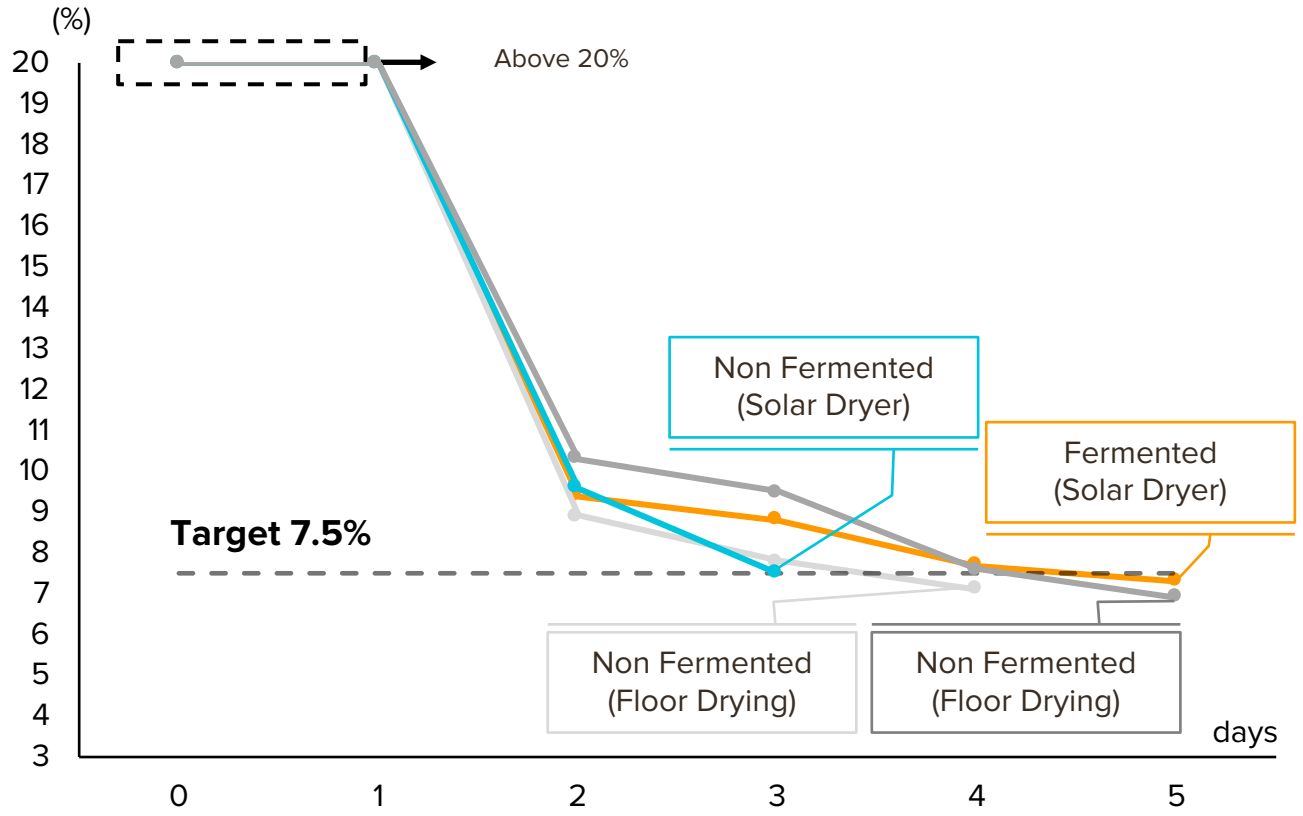
Effort by farmers

Minutes spent/day; N=2 farmers



Time to dry

Moisture (%); N=4 Randomized samples

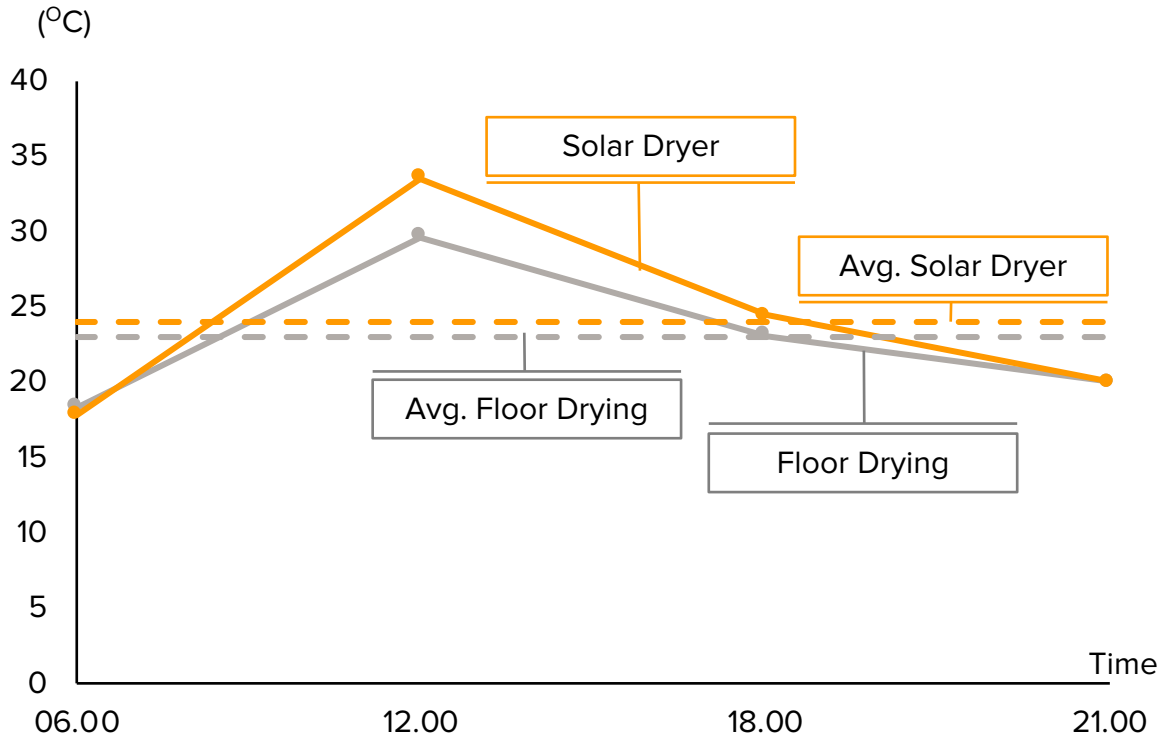


CACAO

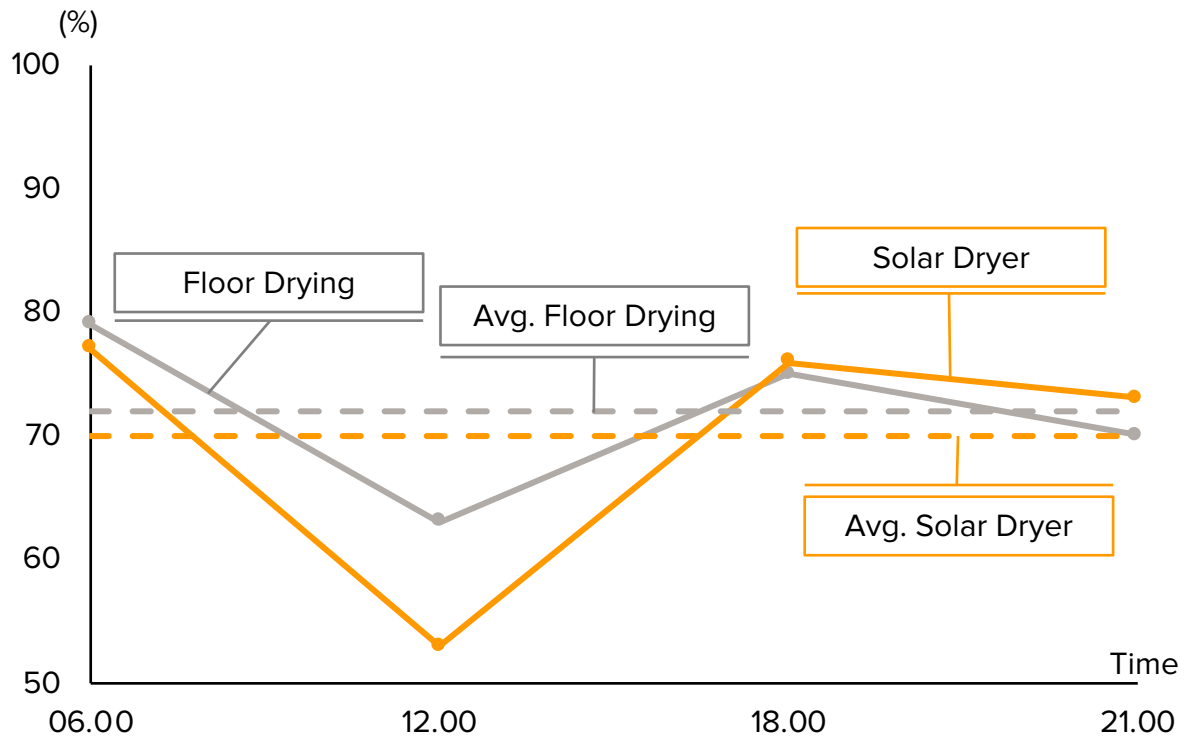
The solar dryer was able to reach higher temperatures and reduce humidity during the day.

Drying performance

Average temperature °C, N= 6 days



Average humidity %, N=6 days



CACAO

The results of the analysis conducted on the bean samples by experts, premium buyers and middlemen indicate that solar dried fermented beans are preffered and have a higher price in the market.

	TREATMENT GROUP – Solar dryer						CONTROL GROUP – Floor drying					
	Fermented			Non Fermented			Fermented			Non Fermented		
	Expert	Premium buyer	Middle-men	Expert	Premium buyer	Middle-men	Expert	Premium buyer	Middle-men	Expert	Premium buyer	Middle-men
Moisture (%) *Max. 7.5%*	7.3	7.2	7.5	7.5		7.5	7.1	7.3	7.6	6.9		7.5
Color	Brown	Brown	Brown	Brown	*Does not accept non-fermented beans*	Purple	Brown	Brown	Brown	Brown	*Does not accept non-fermented beans*	Purple
Mold (%)	0	0	0	0		0	0	0	0	0		0
Slaty (%)	0	0	0	0		0	0	0	0	0		0
Insects (%)	0	0	0	0		0	0	0	0	0		0
Grade	B	B	B	B		A	A	A	A	C		A
Smell/Scent	-	Honey	-	-		-	-	Honey & citrus	-	-		-
Price/kg (IDR)	~48.000	-	~34.000	~25.000		~30.000	< 48.000	-	~34.000	~25.000		~30.000

The grade relates to the quality of cacao trees (eg. how well the trees are taken care of, pests – not the post-harvest process).

- Bean count based on the size of bean

Grade	Total beans/100g
AA	< 85
A	86 - 100
B	101 - 110
C	>110

- Acceptable abnormal beans

Bean condition	Max.
Mold	4%
Purple	3%
Insects	1%
Slaty	2%

- Color of bean indicator

Color	Remarks
Black	Very bad
Purple	Bad
Partly Brown	Good
Brown	Very Good

CACAO

Summary of the key factors: among the four experimentation groups, solar dried fermented beans showed good results where it required less effort by farmers during the drying process and can be sold at a higher price.

		Time to dry	Effort	Moisture content	Price	
Solar Dryer (Treatment Group)	Fermented	✓✓	✓✓✓	✓✓	✓✓✓	10
	Non fermented	✓✓✓	✓✓✓	✓✓	✓	9
Floor Drying (Control Group)	Fermented	✓✓	✓	✓✓	✓✓✓	9
	Non Fermented	✓✓	✓	✓✓	✓	6

✓ = Poor
✓✓ = Moderate
✓✓✓ = Good

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CACAO

Based on the experiment results, we recommend that farmers sort, ferment, and dry the beans in a solar dryer to meet the requirments of premium buyers which can result in a higher selling price.

Post harvest processing

Sorting

- Sorting good beans (removing defective ones) early on will affect the overall quality of the dried beans and lead to a higher price.

Fermentation

- The fermentation process creates a depth of flavor.
- Premium buyers require well fermented dried beans to produce high-quality cacao products.
- A proper fermentation process is best done in a wooden box covered with banana leaves.

Solar drying

- Drying beans in a solar dryer protects beans from rain and other contaminants.
- Farmers spend less time and effort to administer drying process.

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EXPERIMENT RESULTS COFFEE

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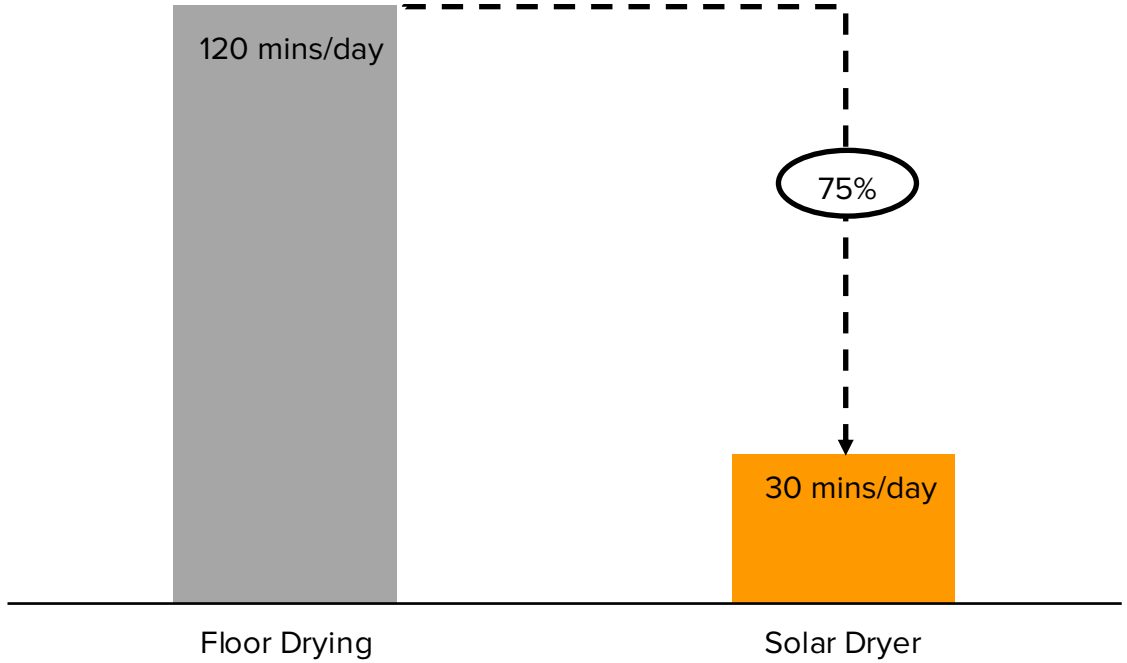
COFFEE – NATURAL PROCESS

The number of days to reach the required moisture level of 12.5% was the same for the solar dryer and open floor drying methods. However, the solar dryer reduced the time and effort required by farmers during the drying process by 75%.

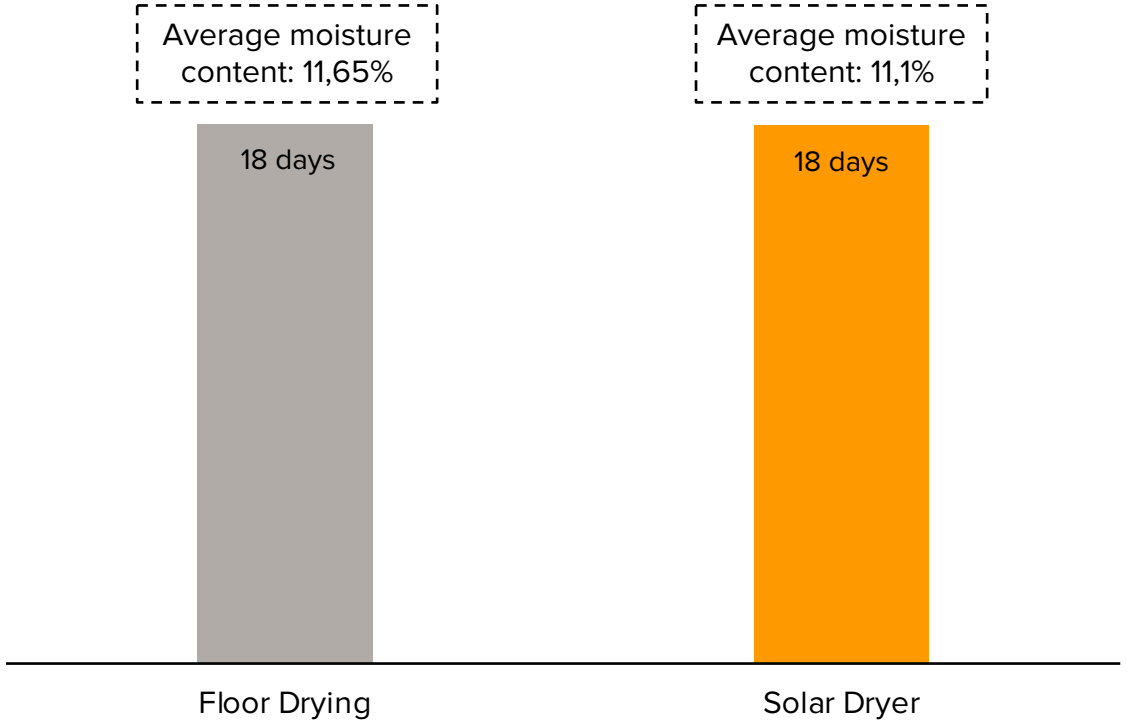
Effort by farmers

Minutes spent; N=2 farmers



Time to dry

Number of days; N=1 each process

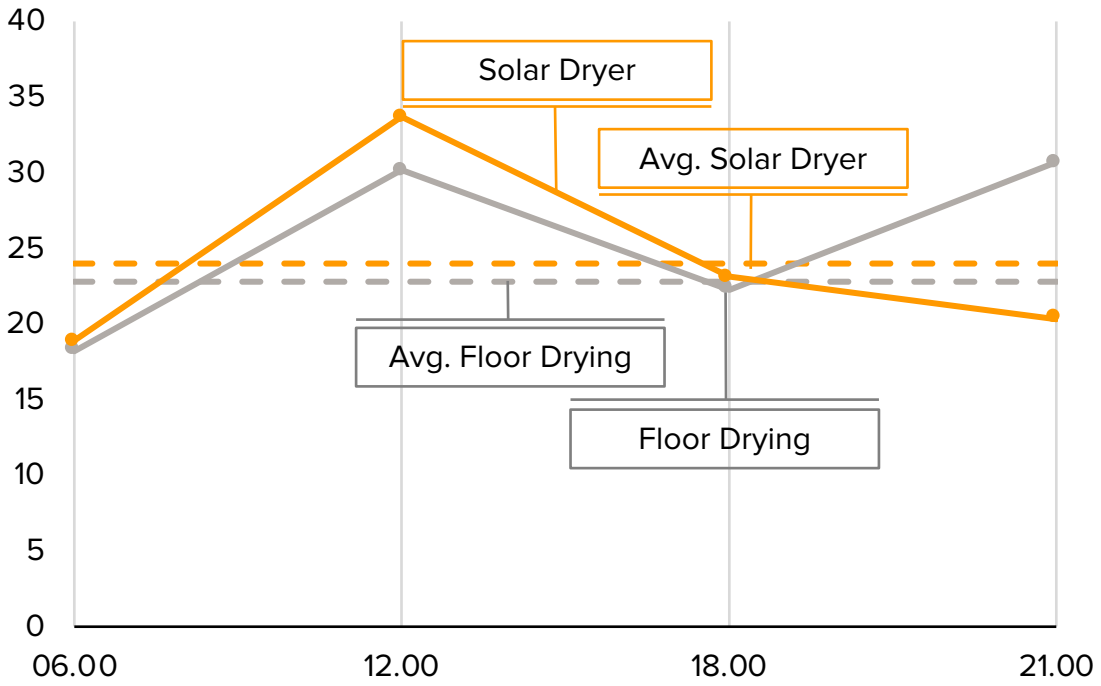


COFFEE – NATURAL PROCESS

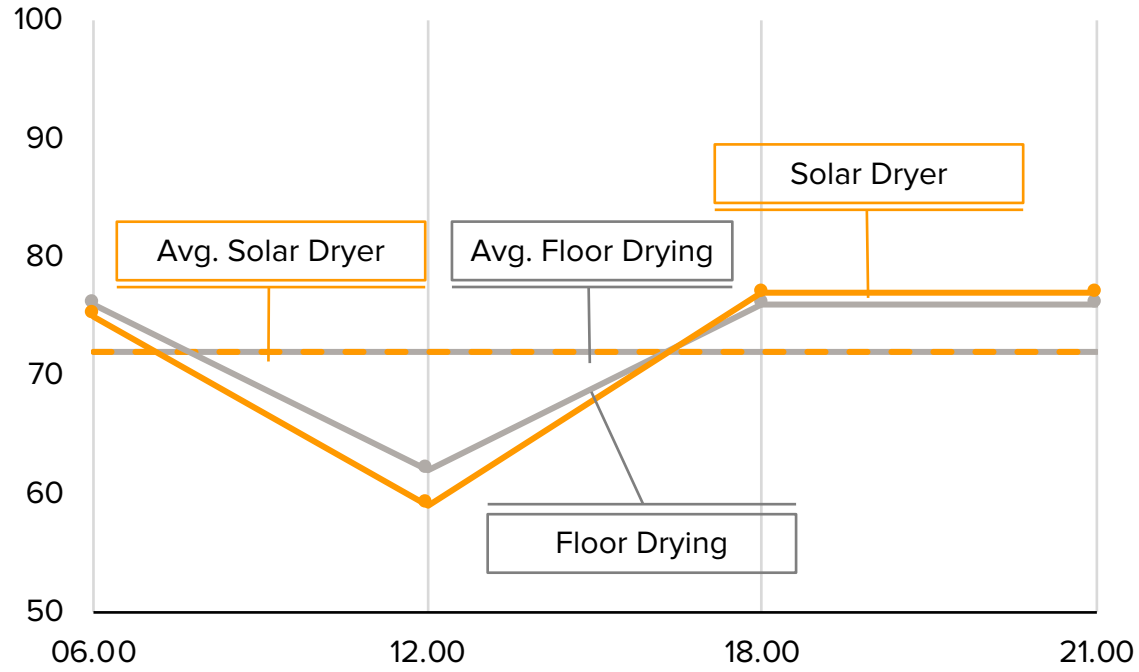
There was no significant difference in the drying performance between the solar dryer and open floor drying methods for the natural process coffee beans. This was due to frequent rain and limited sun exposure at the time of the experiment.

Drying performance

Average temperature °C, N=21 days



Average humidity %, N=21 days

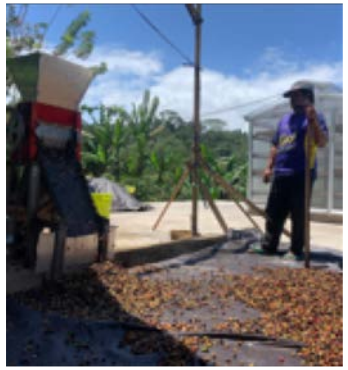


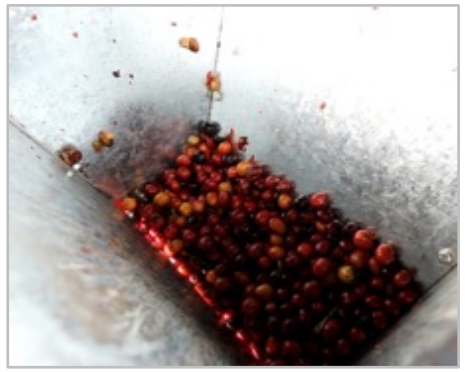
COFFEE – HONEY PROCESS

Honey process beans are highly desired by premium coffee buyers and have a higher value in the market. We conducted an additional experiment using the honey process combined with the solar dryer. The beans reached the required moisture level within 8 days (compared to 21 days for the natural process).

Honey process

De-pulping





- Opening of the coffee cherry skin using a pulping machine prior to drying.

Solar drying

- The beans are dried with the mucilage layer still intact.
- During the drying process, the mucilage layer will absorb the air moisture that will make the beans sticky resembling the texture of honey.

Testing

- The dried beans were assessed by three different buyers; Conventional buyer, premium buyer, and middlemen.

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COFFEE

The results of analysis of bean samples sent to various buyers show that honey processed beans are preffered and priced higher in the market among conventional and premium buyers. The premium buyer considered the honey processed beans to be 'fine robusta' – a highly valued and sought-after quality of coffee.

	TREATMENT GROUP			CONTROL GROUP			Solar dryer		
	Solar dryer			Floor drying			Honey Process		
	Natural Process			Natural Process					
	Conventional buyer	Premium buyer	Middle-men	Conventional buyer	Premium buyer	Middle-men	Conventional buyer	Premium buyer	Middle-men
Moisture (%) *Max. 12.5%*	-	-	20	-	-	17.5	10.3	10.3	18
Grade	93	79.75	-	92	80.1	-	93	83	-
Defects (%)	7	10	7	8	10	0	7	0	4
Price/kg (IDR)	~25.000	~28.000	~19.500	~25.000	~28.000	~30.000	~28.000	~35.000	~20.000

Grade levels of premium buyer applying cupping and tasting process.

- Indicator for cupping

Indicator	Scale
Fragrance	Dry/Break (6-10)
Flavor	6-10
Aftertaste	Brackish/Savory (6-10)
Salt/Acid	Low Salt/Hi Acid (6-10)

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- Tasting scale

Indicator	Scale
Bitter/Sweet	Low Bitter/Hi Sweet (6-10)
Mouthfeel	Rough/Smooth (6-10)
Uniform Cups	Comparing 5 cups
Balance	6-10
Clean Cups	Comparing 5 cups

=

- Bean grade

Indicator	Scale
Overall bean quality	50 (average)
	60 (good)
	70 (very good)
	80 (Fine)
	90 (Outstanding)

Conventional buyer and middleman grade the beans based on defect count and moisture level.

- Bean grade

Grade	Total beans/100g
Good	91-100
Moderate	81 - 90
Poor	< 80

COFFEE

Summary of the key factors: honey processed coffee beans combined with a solar dryer showed good results where it took less time to dry, required less effort by farmers, and can be sold at a higher price.

		Time to dry	Effort	Moisture content	Price	
Natural Process	Solar Dryer (Treatment Group)	✓✓	✓✓✓	✓✓	✓✓	9
	Floor Drying (Control Group)	✓✓	✓	✓✓	✓✓	7
Honey Process	Solar Dryer	✓✓✓	✓✓✓	✓✓✓	✓✓✓	12

✓	= Poor
✓✓	= Moderate
✓✓✓	= Good

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COFFEE

Based on the experiment results, we recommend farmers to first sort their coffee to remove defective cherries, and diversify their coffee post-harvest process to include the honey process combined with the solar dryer method in order to reach higher-end market segments with a higher selling price.

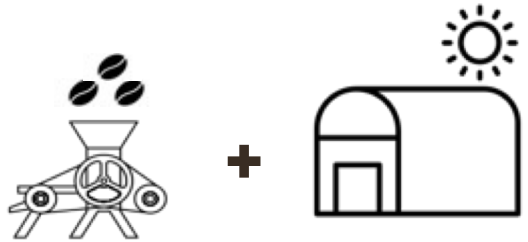
Post harvest processing

Sorting

- Sorting good beans (removing defected ones) using a water floating process early on will reduce the risk of beans being bought at a lower price.

Drying

Honey process



- Putting the coffee cherries through a pulper and drying them in the solar dryer will result in higher quality beans.

Roasting, cupping and tasting of honey-processed beans by premium buyer.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NEXT STEPS

Upon completion of the experiment, we conducted a **dissemination event to share our findings and lessons learned from the experiment with farmers, buyers and local government officials.** There was a high level of interest among the attendees to adopt the solar dryer. Farmers and the head of a farmers' group shared their experiences of being unable to dry cacao and coffee beans during the rainy season, which led to bean spoilage and negatively impacted their income. From the farmers' perspective, the solar dryer would effectively address their drying challenges, especially during the rainy season.

Moving forward, Kopernik will:

- Conduct discussions with other local government officials, village authorities and farmer groups to introduce the technology and improved post-harvest processing and the potential benefits for farmers. and to determine whether the village fund mechanism (Dana Desa) can be utilised to provide solar drying technology for coffee and cacao farmers in the area.
- Seek funding to provide continued support to farmers in Tabanan in the post-harvest process for coffee and cacao and to connect them to markets, especially to premium buyers.

Dissemination event in Desa Sanda, Pupuan, Tabanan, Bali

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ACKNOWLEDGEMENTS

This report was written by Nanda Riska, Associate Director of Solutions Lab and Mohamad Dwi Ergianto, Analyst at Solutions Lab, Kopernik.

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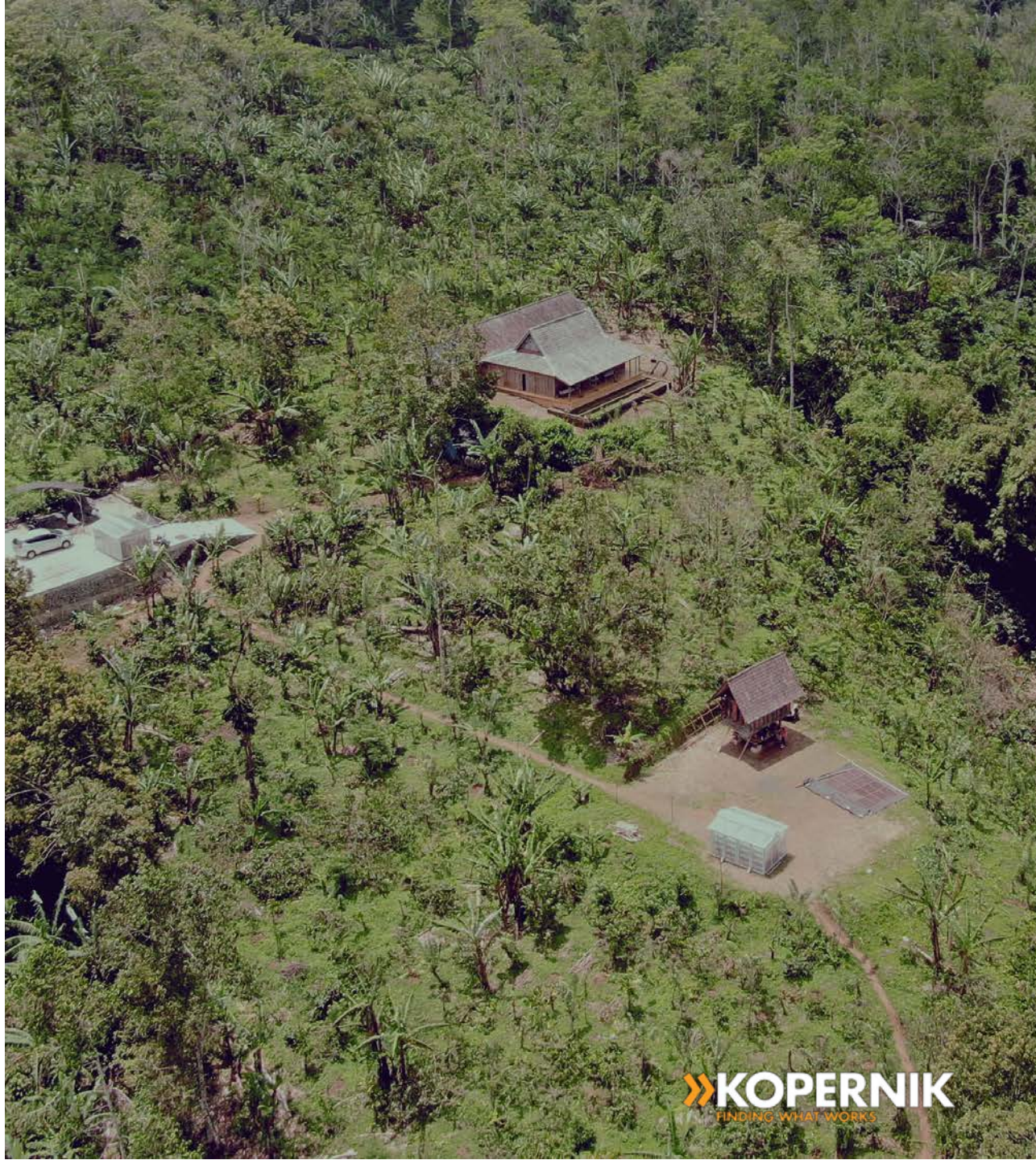

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