P5 | **A vision for biobased houses in the tropics**

Personal information

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Architectural Engineering
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Second tutor: Pierre Jennen
Research tutor: Martin Tenpierik
External examiner: Ype Cuperus

Image source: own illustration

Image source: own illustration

Image source: own illustration

Image source: own illustration

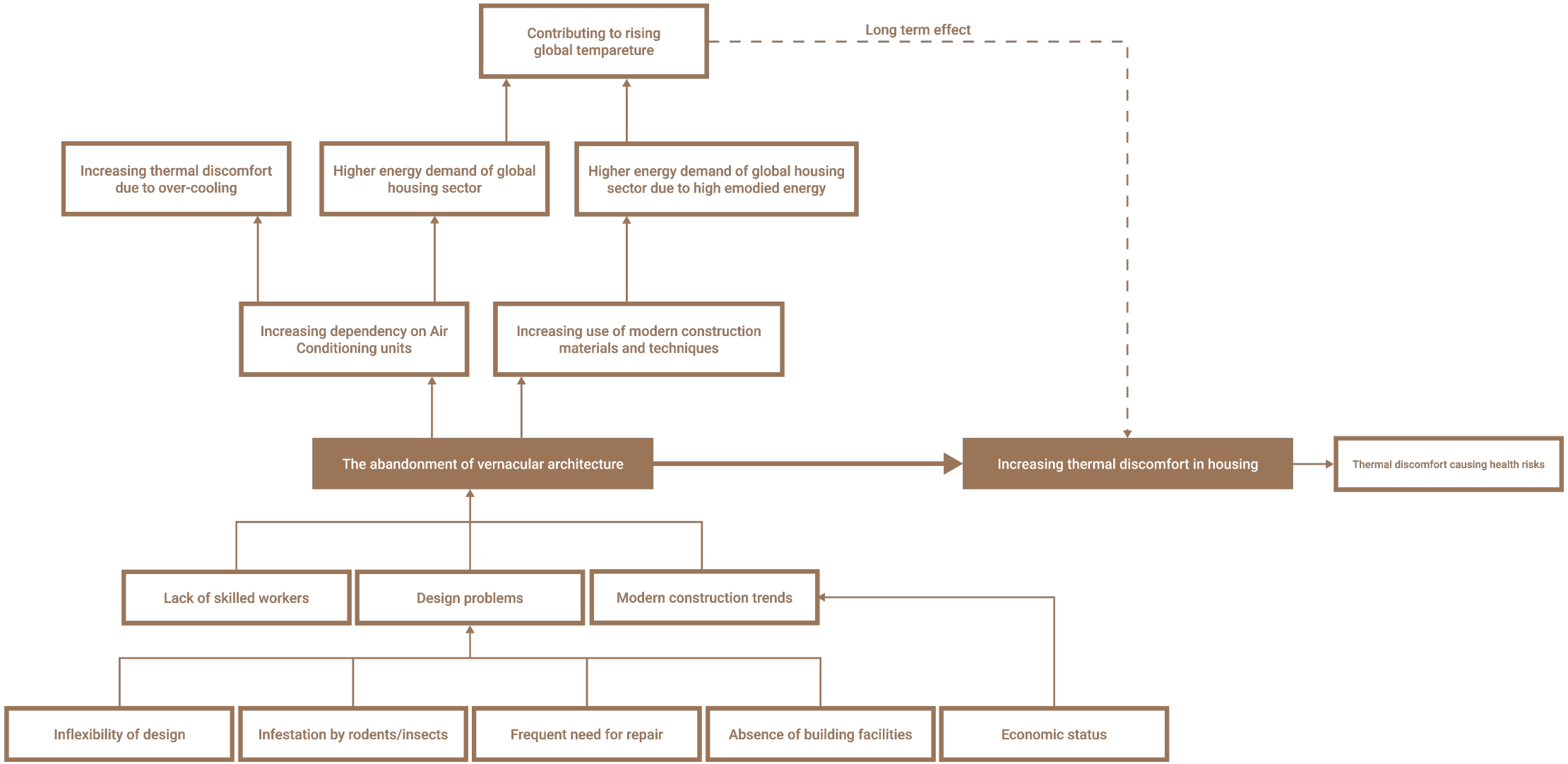
Problem statement

Design question

Research question

Design criteria I - V

Design proposal



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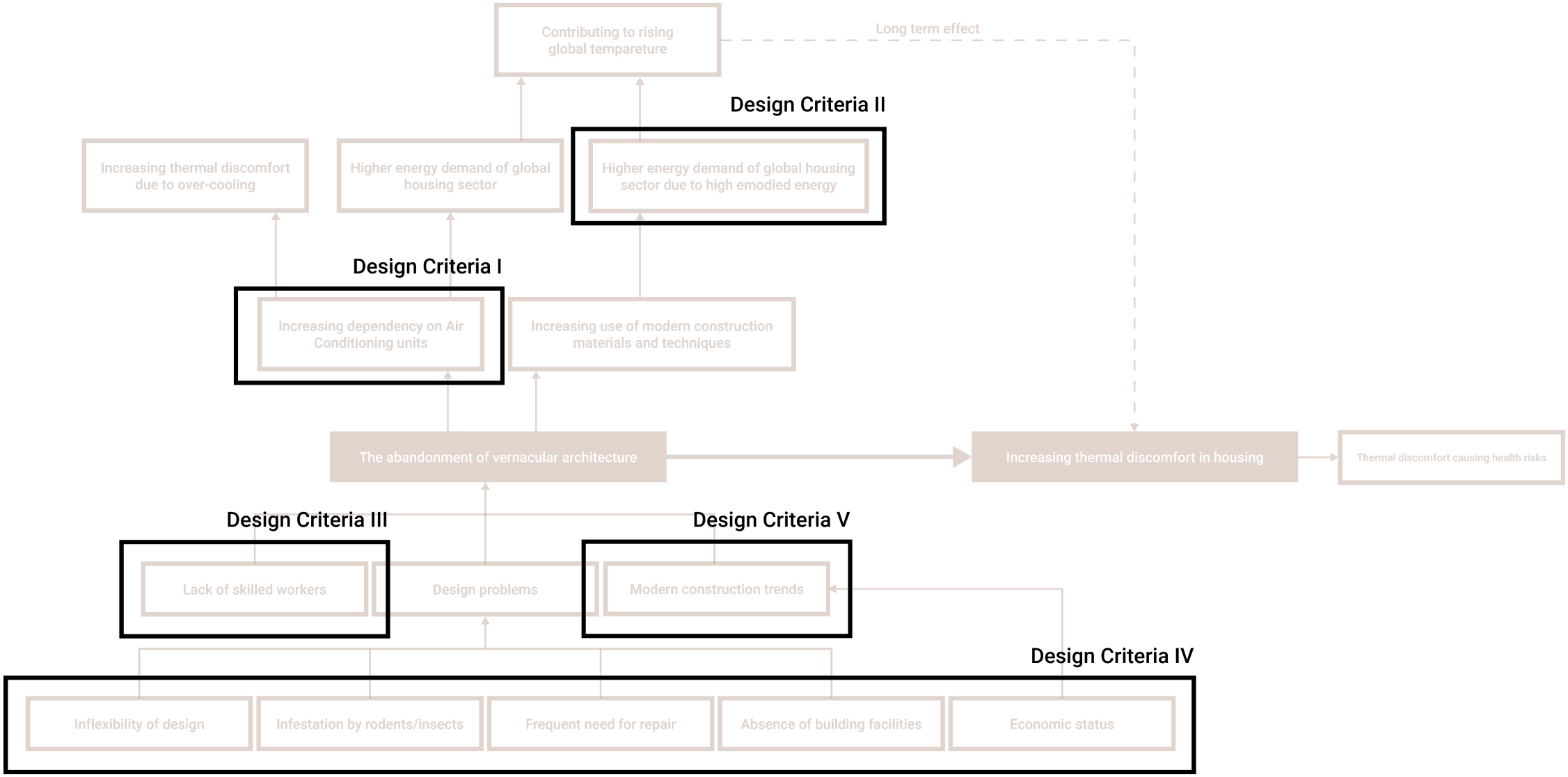


Image source: own illustration

Problem statement - Design question - Research question - Design criteria I - Design criteria II - Design criteria III - Design criteria IV - Design criteria V - Design proposal

Design Criteria I:	Passively provide [adaptive] thermal comfort
Design Criteria II:	Fully bio-based
Design Criteria III:	Buildable with local construction workers
Design Criteria IV:	Accessible for low-income people
Design Criteria V:	Building system that can be implemented throughout tropical climate region

Problem statement

Design question

Research question

Design criteria I - V

Design proposal

How can we design a **fully bio-based** building system that can be easily **constructed by local workers**, is **accessible to low-income people**, **passively provides thermal comfort** and can be effectively implemented across the **tropical climate region**

Problem statement

Design question

Research question

Design criterial I - V

Design proposal

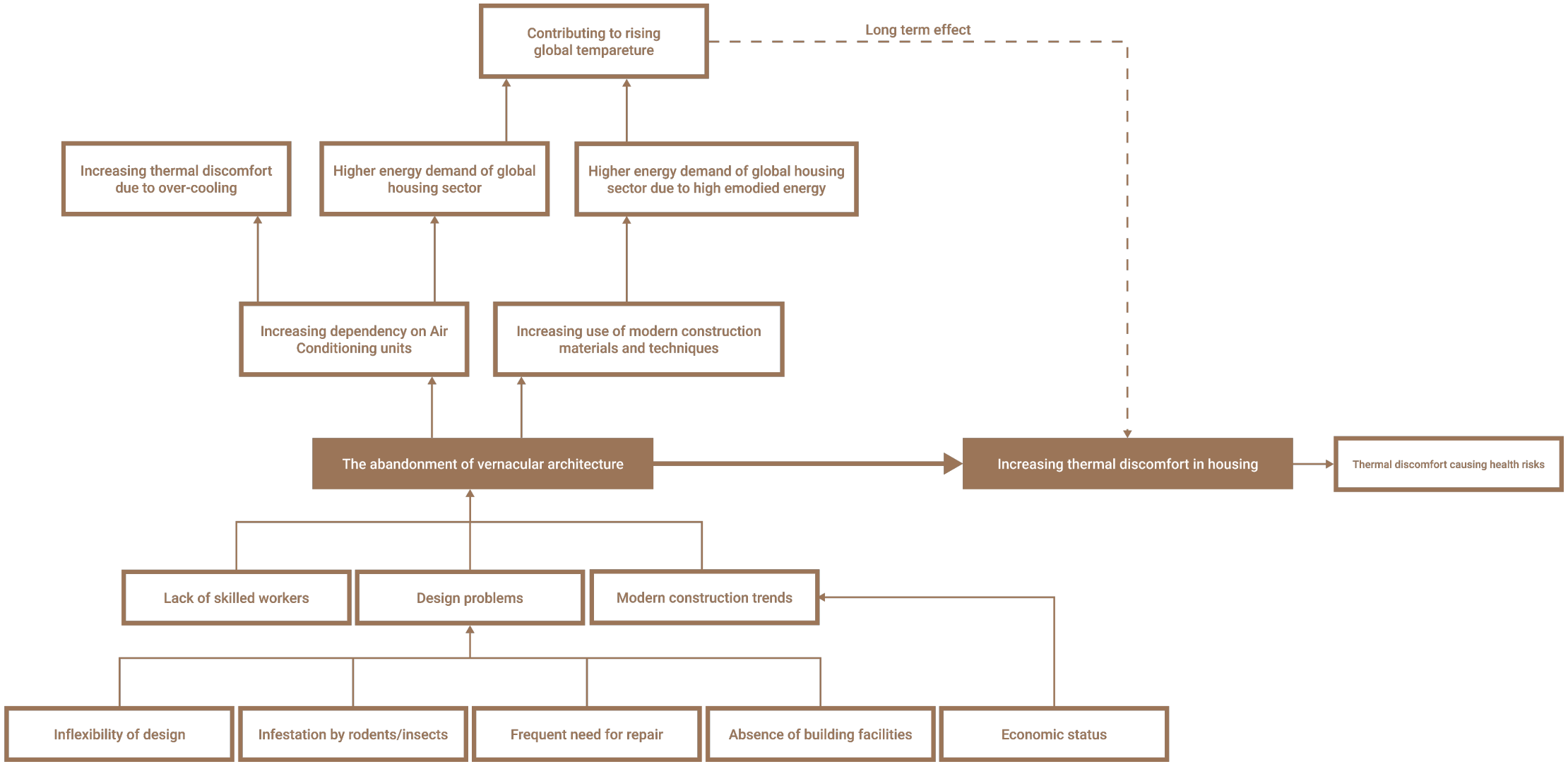
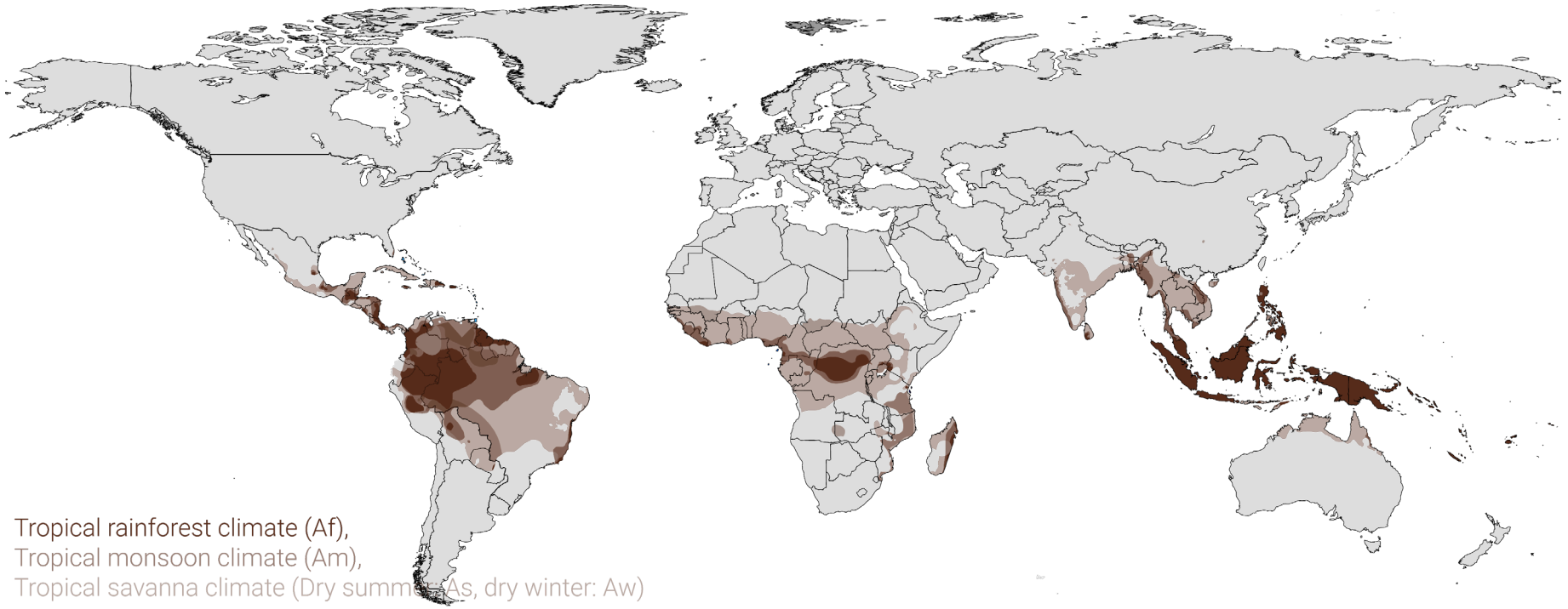


Image source: own illustration

How and to what extend do **bioclimatic strategies** in **vernacular architecture** provide adaptive **thermal comfort** in a tropical monsoon climate?

Tropical climate Köppen climate classification [A]



Tropical rainforest climate (Af),
Tropical monsoon climate (Am),
Tropical savanna climate (Dry summer: As, dry winter: Aw)

Image source: own illustration

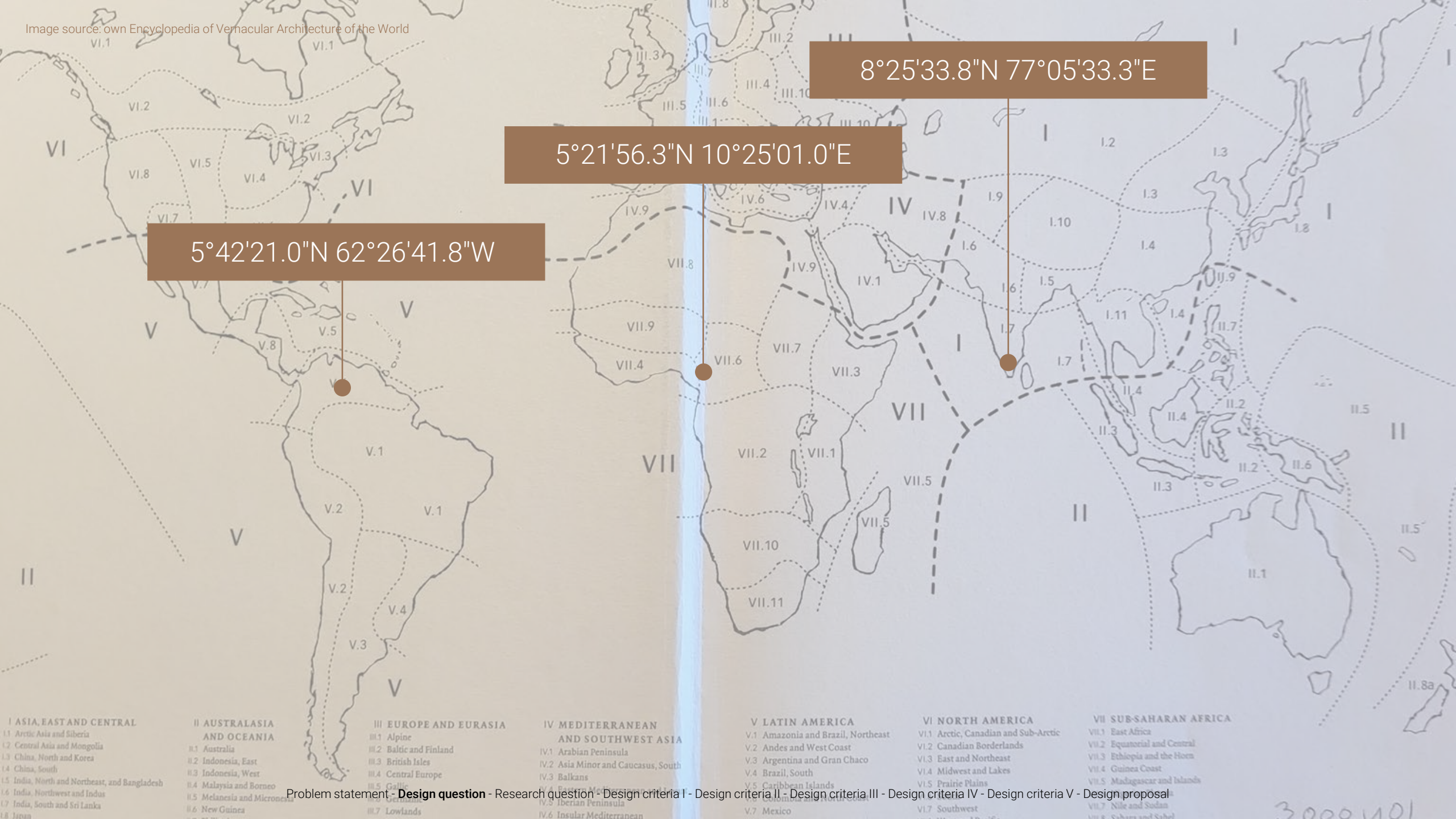
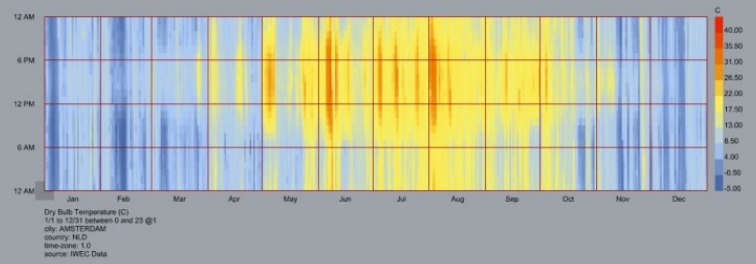


Image source: own Encyclopedia of Vernacular Architecture of the World
8°25'33.8"N 77°05'33.3"E
5°21'56.3"N 10°25'01.0"E
5°42'21.0"N 62°26'41.8"W
I ASIA, EAST AND CENTRAL
I.1 Arctic Asia and Siberia
I.2 Central Asia and Mongolia
I.3 China, North and Korea
I.4 China, South
I.5 India, North and Northeast, and Bangladesh
I.6 India, Northwest and Indus
I.7 India, South and Sri Lanka
I.8 Japan
II AUSTRALASIA AND OCEANIA
II.1 Australia
II.2 Indonesia, East
II.3 Indonesia, West
II.4 Malaysia and Borneo
II.5 Melanesia and Micronesia
II.6 New Guinea
III EUROPE AND EURASIA
III.1 Alpine
III.2 Baltic and Finland
III.3 British Isles
III.4 Central Europe
III.5 Gallic
III.7 Lowlands
IV MEDITERRANEAN AND SOUTHWEST ASIA
IV.1 Arabian Peninsula
IV.2 Asia Minor and Caucasus, South
IV.3 Balkans
V LATIN AMERICA
V.1 Amazonia and Brazil, Northeast
V.2 Andes and West Coast
V.3 Argentina and Gran Chaco
V.4 Brazil, South
V.5 Caribbean Islands
V.7 Mexico
VI NORTH AMERICA
VI.1 Arctic, Canadian and Sub-Arctic
VI.2 Canadian Borderlands
VI.3 East and Northeast
VI.4 Midwest and Lakes
VI.5 Prairie Plains
VI.7 Southwest
VII SUB-SAHARAN AFRICA
VII.1 East Africa
VII.2 Equatorial and Central
VII.3 Ethiopia and the Horn
VII.4 Guinea Coast
VII.5 Madagascar and Islands

Dry Bulb Temperature [Hourly plot]

Netherlands



Tropical monsoon climate

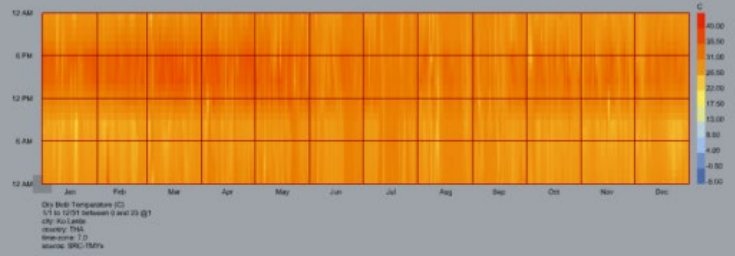
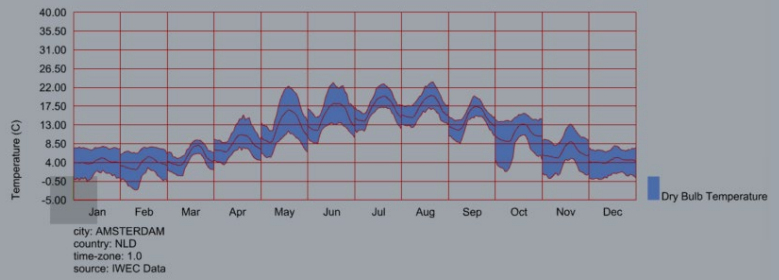


Image source: own illustration

Dry Bulb Temperature [Monthly plot]

Netherlands



Tropical monsoon climate

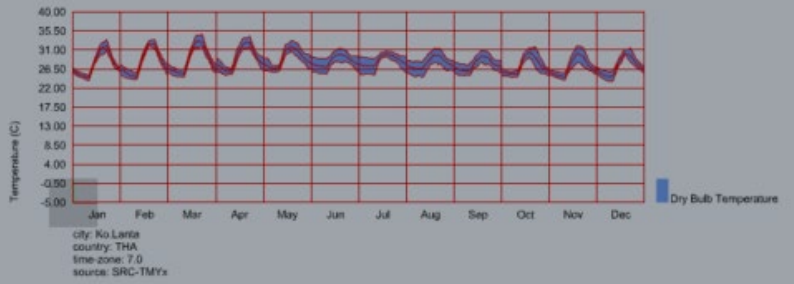
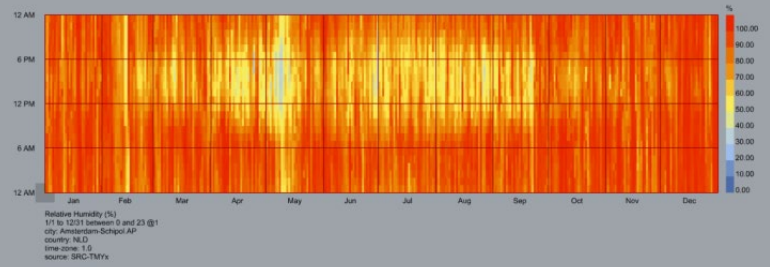


Image source: own illustration

Relative Humidity [Hourly plot]

Netherlands



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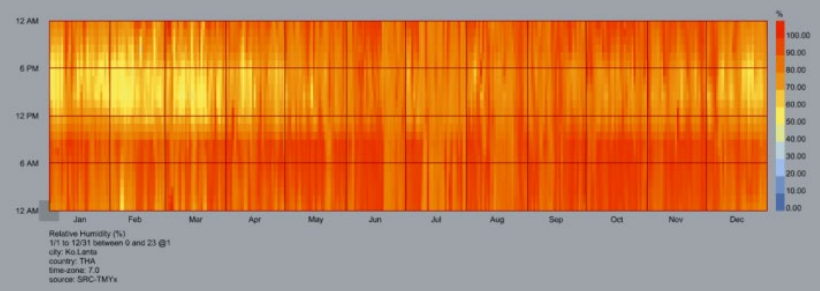

Image source: own illustration

Relative Humidity [Monthly plot]

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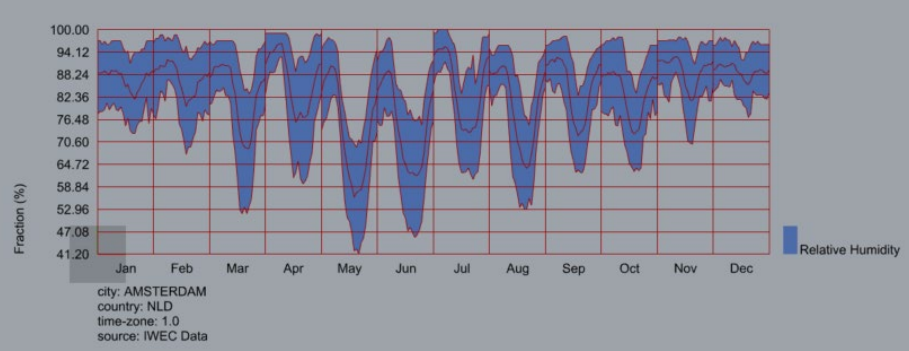


Tropical monsoon climate

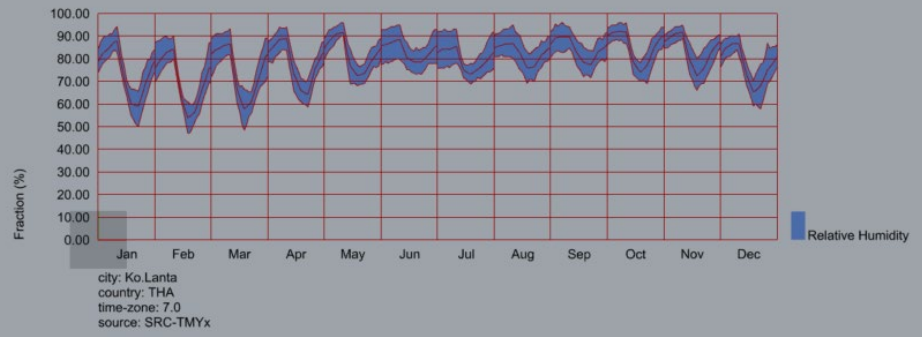
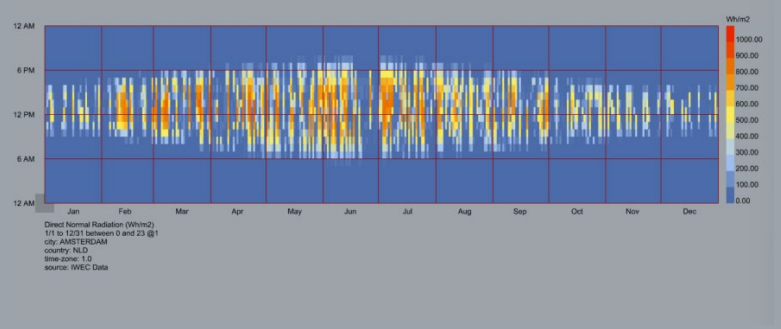


Image source: own illustration

Solar radiation [Hourly plot]

Netherlands



Tropical monsoon climate

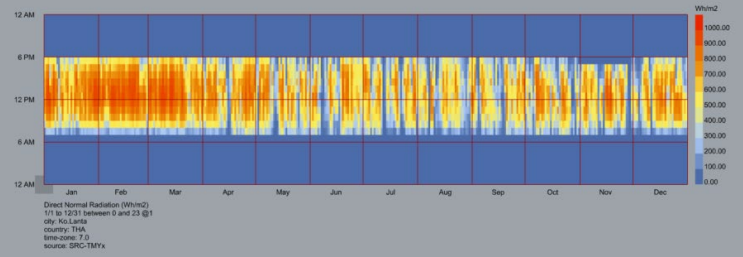
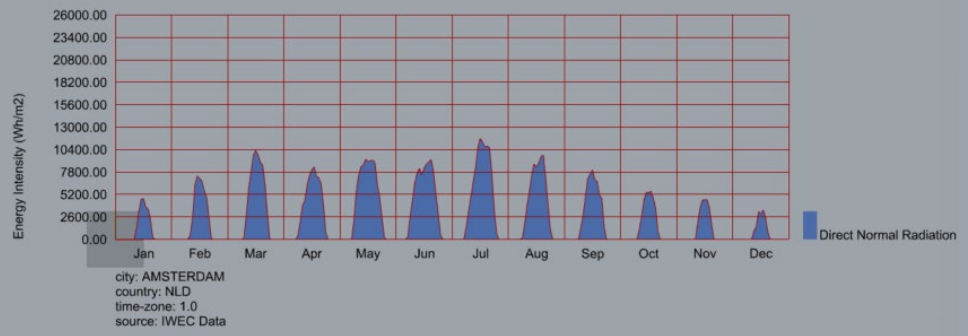


Image source: own illustration

Solar radiation [Monthly plot]

Netherlands



Tropical monsoon climate

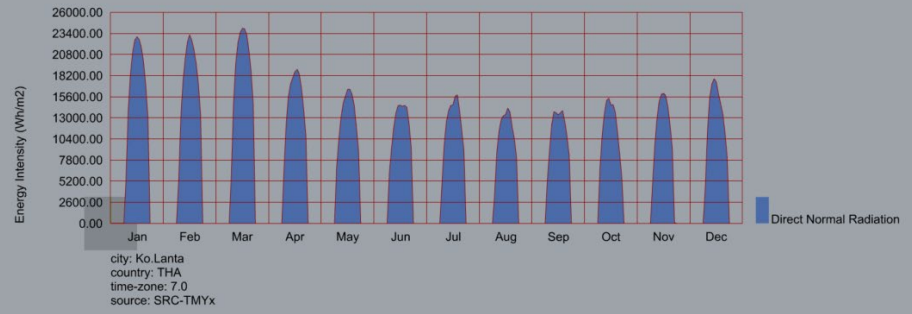
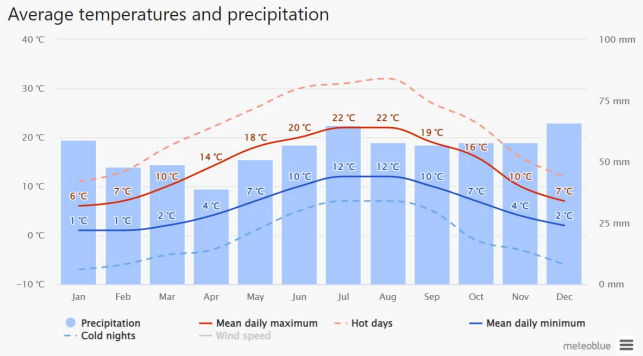


Image source: own illustration

Precipitation [mm]

Netherlands



Tropical monsoon climate

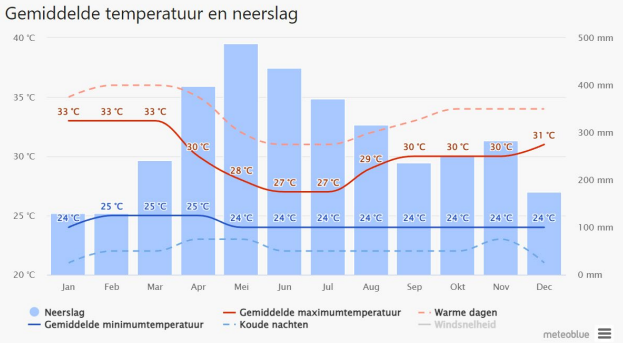


Image source: own illustration

Tropical monsoon climate characteristics

High solar radiation on west, east and horizontal surfaces (constant throughout the day and season)

High average temperature (constant throughout the day and season)

High average relative humidity (constant throughout the day and season)

High precipitation (constant throughout season and increase during monsoons)

Bio-climatic strategies

1.Building orientation and shape

2.Solar shading

3.Natural ventilation (cross ventilation (a), stack ventilation (b), single-side ventilation (c))

4.Natural lighting techniques

5.Light weight construction

6.High thermal mass

7.Evaporative cooling

8.Earth cooling

9.Passive cooling by using color

10.Thermal insulation by material

11.Thermal insulation by design (e.g., well ventilated attic, double-skin façade…)

12.Passive solar energy

13.Storm prevention

14.Flood prevention

15.Rainwater discharge

16.Moisture and condensation prevention

17.Others

Image source: own Encyclopedia of Vernacular Architecture of the World

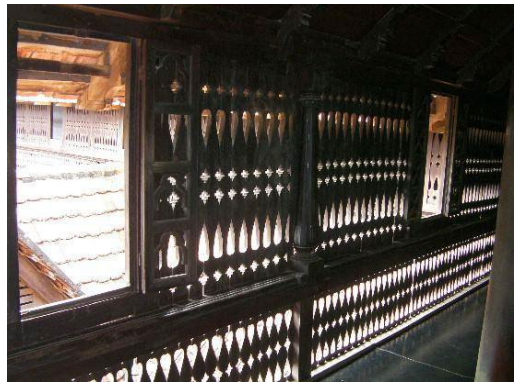
Vernacular architecture Bamileke

Image source: own Encyclopedia of Vernacular Architecture of the World

Vernacular architecture Amazone

Image source: own Encyclopedia of Vernacular Architecture of the World

Vernacular architecture Kerala



Bio-climatic strategies

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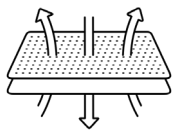
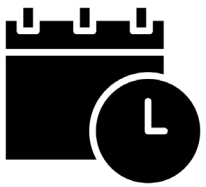
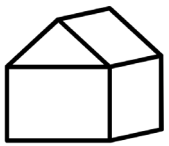
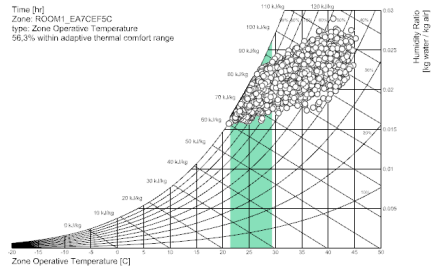
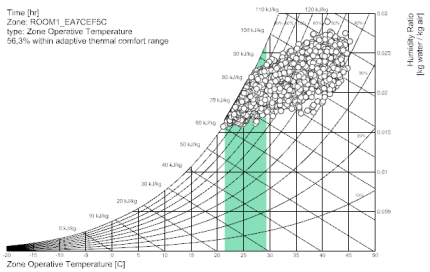


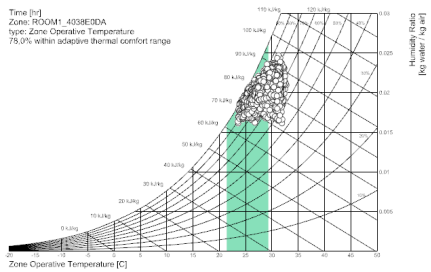





EnergyPlus


Time [hr]
Zone: ROOM1_EA7CEF5C
type: Zone Operative Temperature
56.3% within adaptive thermal comfort range
Humidity Ratio [kg water / kg air]
Zone Operative Temperature [C]





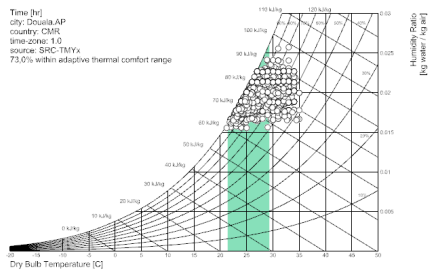


Image source: own illustration

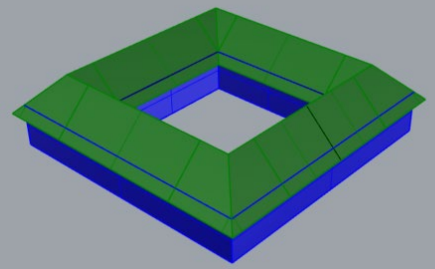
Problem statement

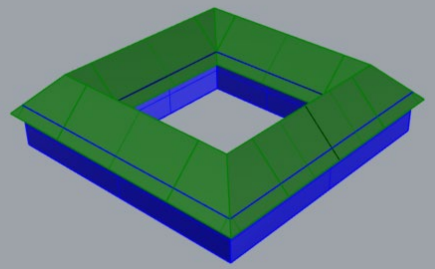
Design question

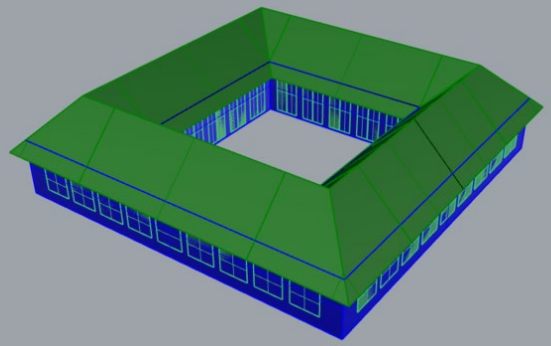
Research question

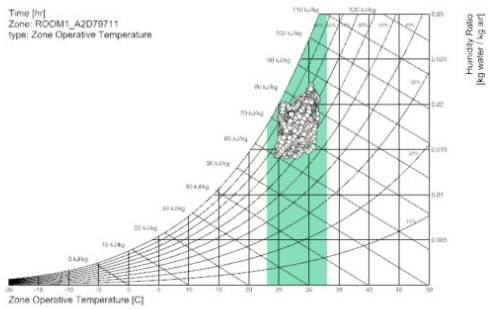
Design criteria I: Passively provide thermal comfort

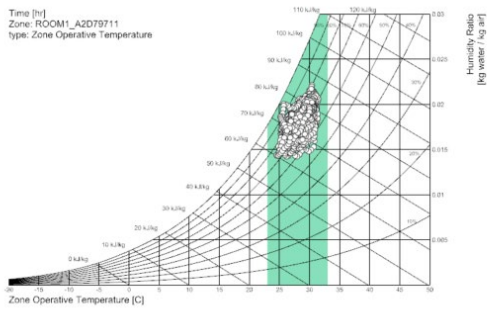
Design proposal

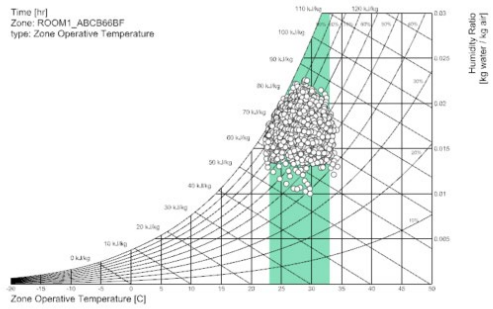












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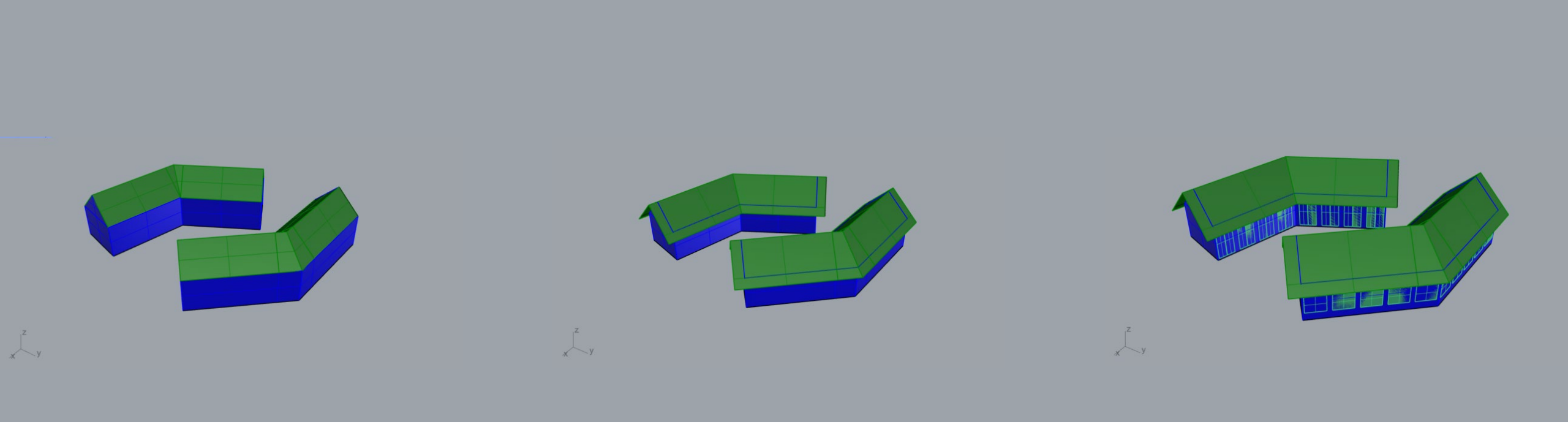

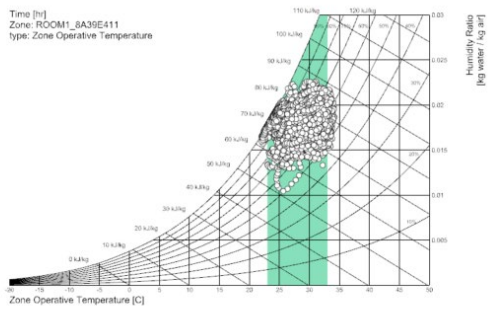

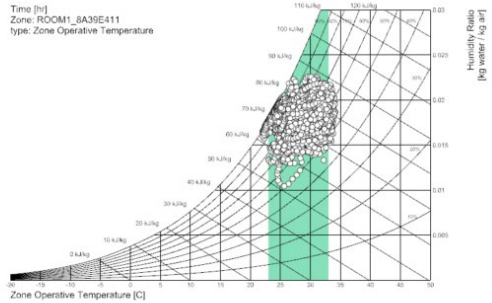

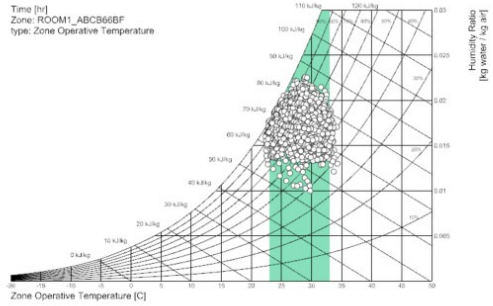

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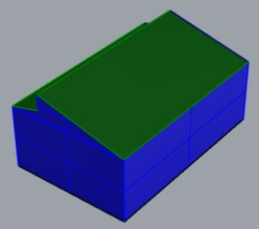

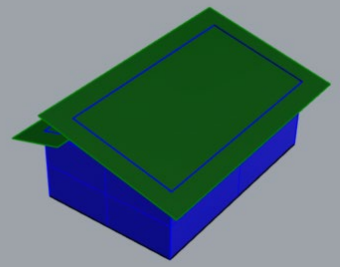

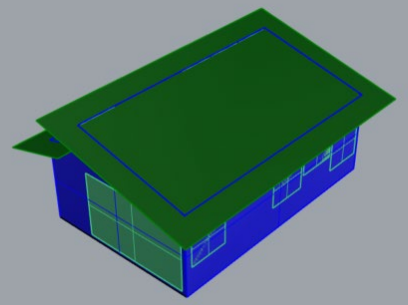

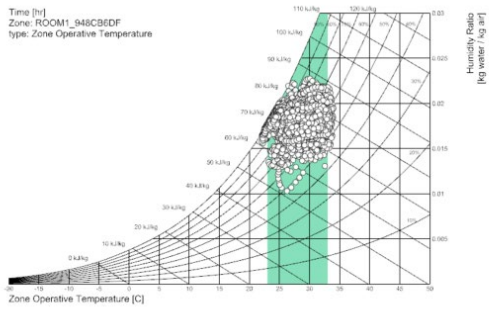

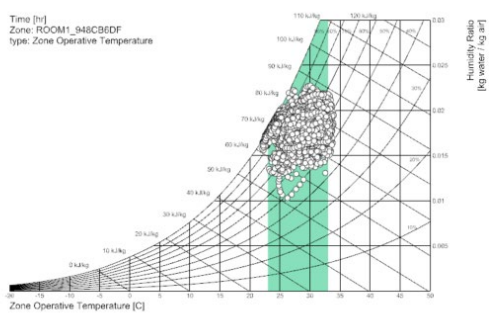

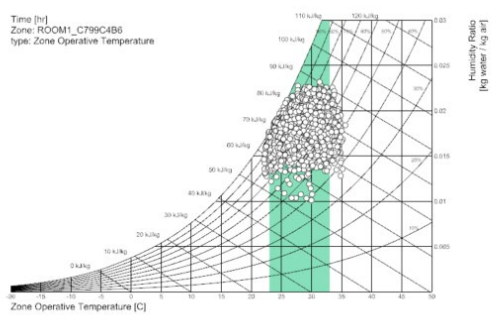

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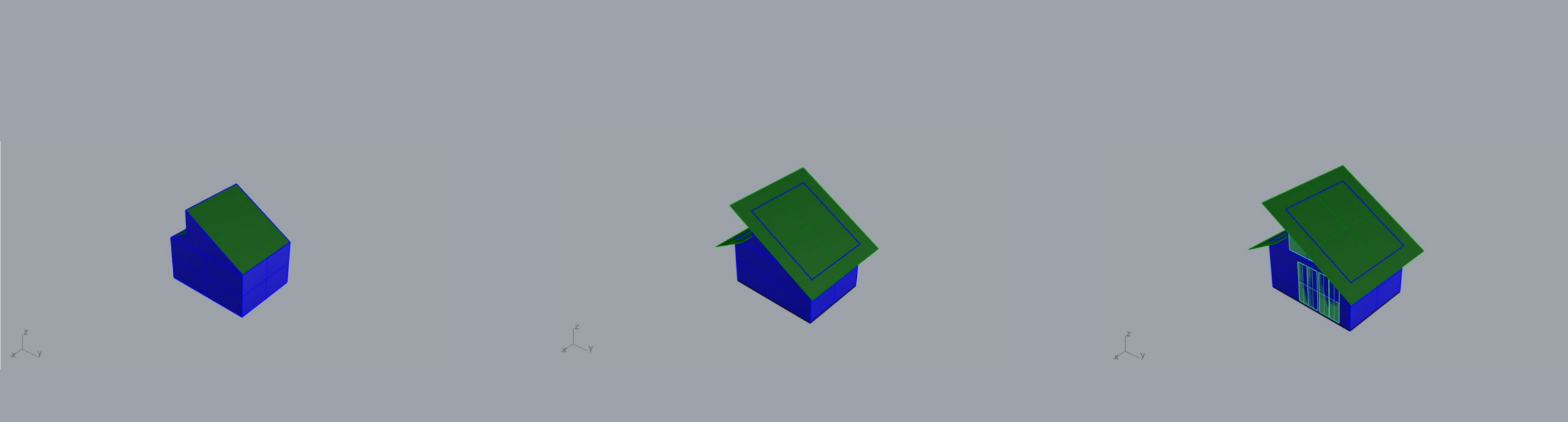

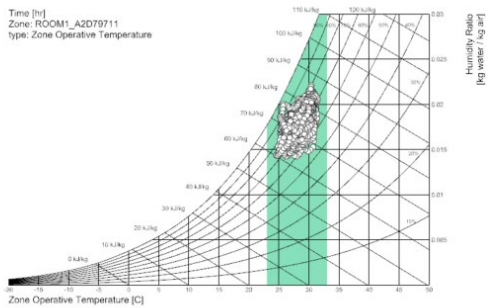

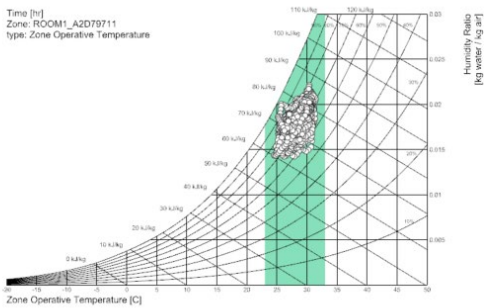

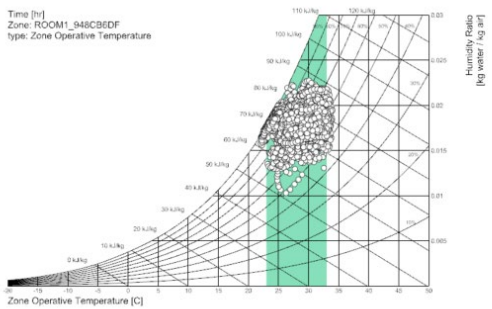

Image source: own illustration

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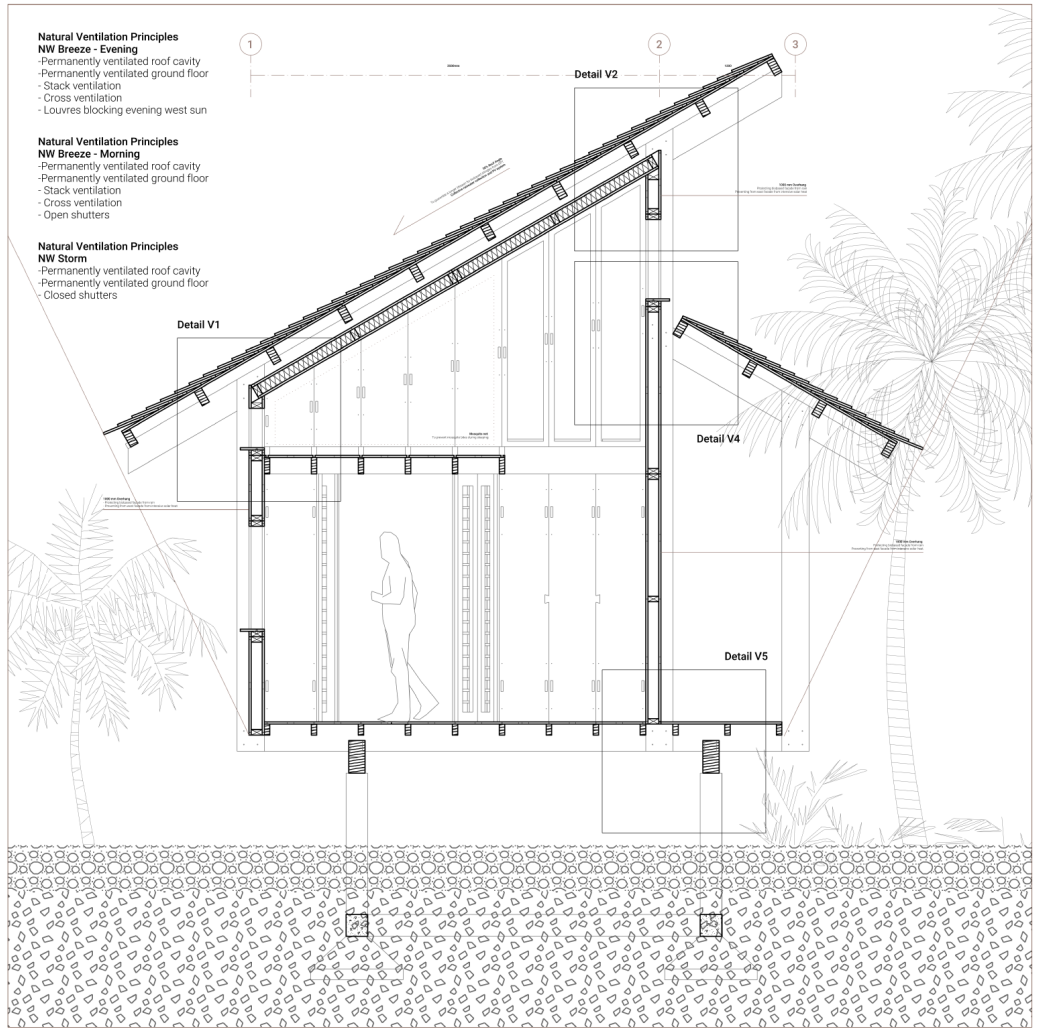
Section AA - Climate Scheme | 1:20



Problem statement

Design question

Research question

Design criteria II: Fully bio-based

Design proposal

Tropical climate (A) Köppen climate classification

Tropical rainforest climate (Af),
Tropical monsoon climate (Am),
Tropical savanna climate (Dry summer: As, dry winter: Aw)

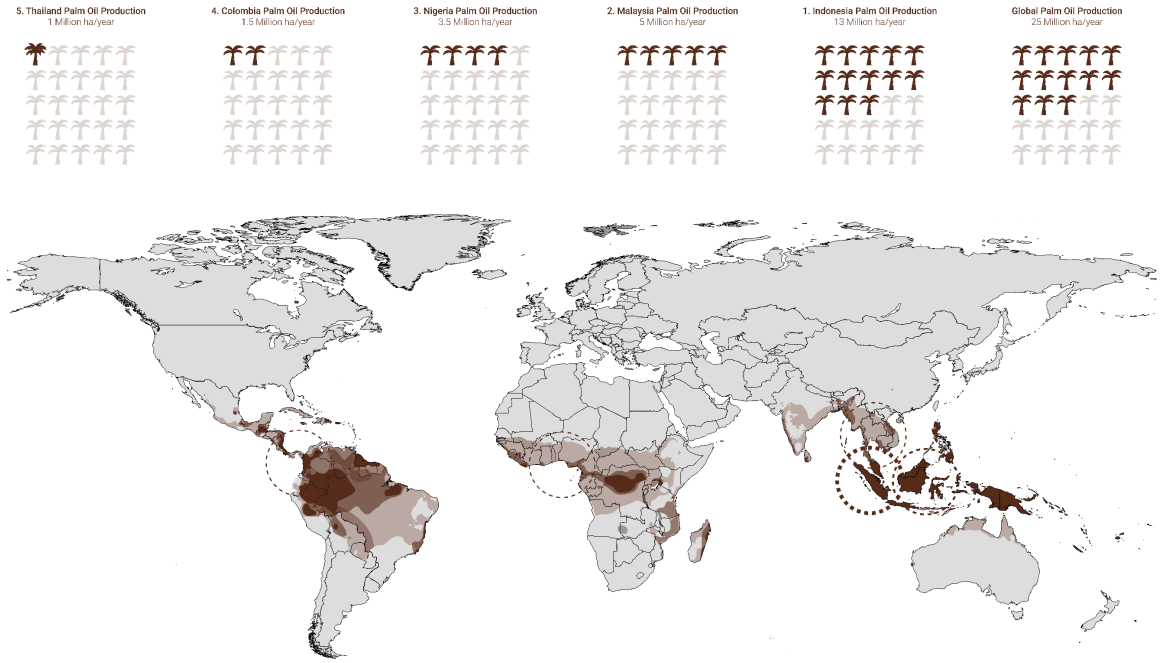


Image source: own illustration

Image source: Glued Laminated Timber from Oil Palm Timber

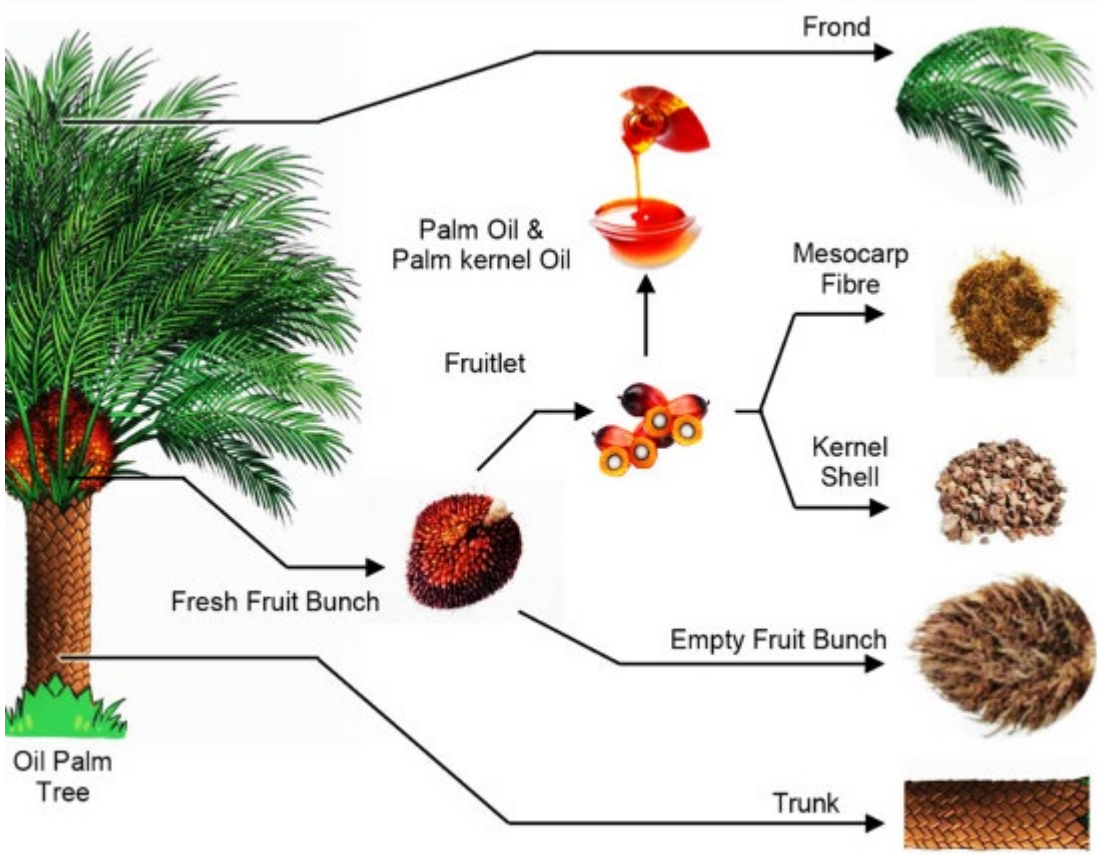


Image source: Glued Laminated Timber from Oil Palm Timber

Table 1: Palms with potential for industrial conversion of trunks into products.

palms	world area [million ha]	number of palms [million]	rotation period [years]	number of available palms [million]	available million m³ [palm trunks per year]
oil palm	25	3,000	25	120	180
coconut palm	12	1,200	50	24	40
date palm	0.8	110	55	2	3

Image source: Glued Laminated Timber from Oil Palm Timber

Table 2: Main growing countries for palms and areas in million ha (various sources).

oil palm		coconut palm		date palm	
Indonesia	13.0	Indonesia	4.0	Iran	0.22
Malaysia	5.0	Philippines	3.5	Iraq	0.21
Nigeria	3.5	India	2.0	UAE	0.16
Thailand	1.0	Brasil	0.5	S. Arabia	0.04
World	>25.0	world	~12.0	world	~1.0

Image source: Glued Laminated Timber from Oil Palm Timber

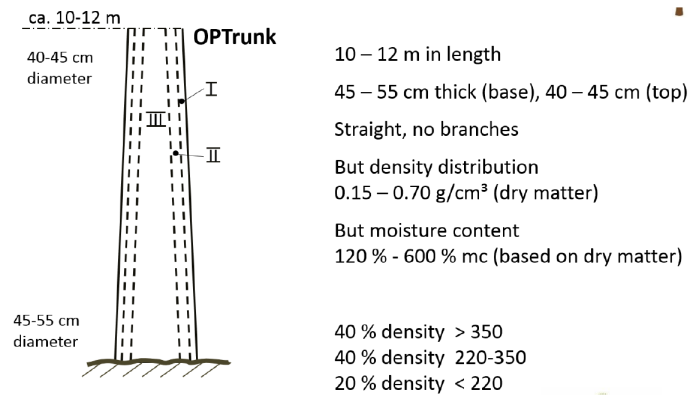


Figure 1: Density distribution in an oil palm trunk.

Image source: Glued Laminated Timber from Oil Palm Timber

Fig. 1 Sawing pattern of the oil palm trunk sections with board identification numbers

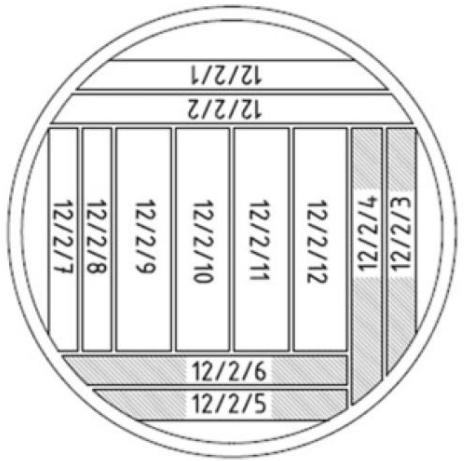


Image source: Glued Laminated Timber from Oil Palm Timber

Fig. 10 shows an overview on the key processes in oil palm wood utilization.

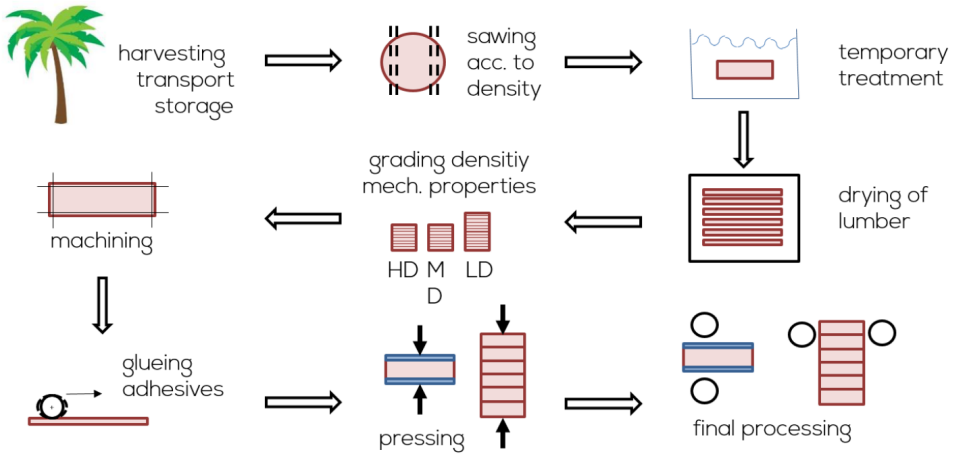


Figure 10: Key processes in palm wood utilization

Image source: Glued Laminated Timber from Oil Palm Timber

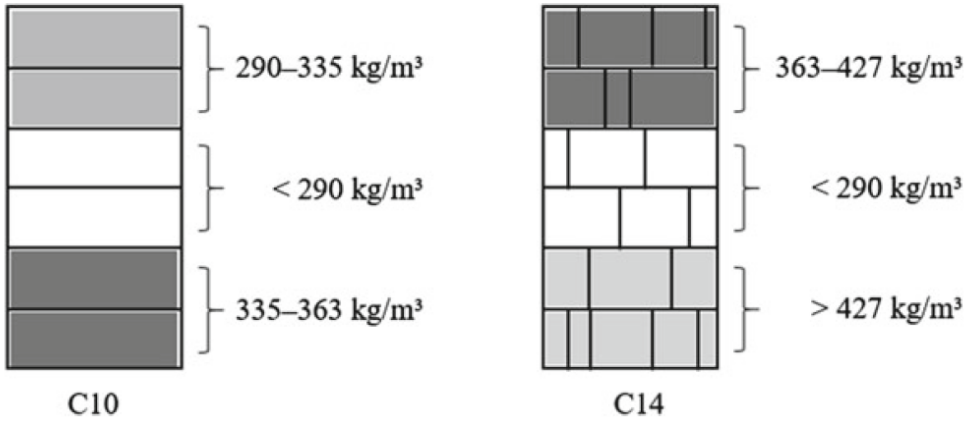


Fig. 5 Combined beam structures to achieve strength class C10 (left) and C14 (right). The left beam is based on non-ripped lamellas, whereas the beam on the right is based on ripped lamellas

Image source: Glued Laminated Timber from Oil Palm Timber

Fig. 7 Typical fracture patterns; left: in compression below the load inducing area and in the area of the supports; right: in tension on a reverse loaded beam

Problem statement

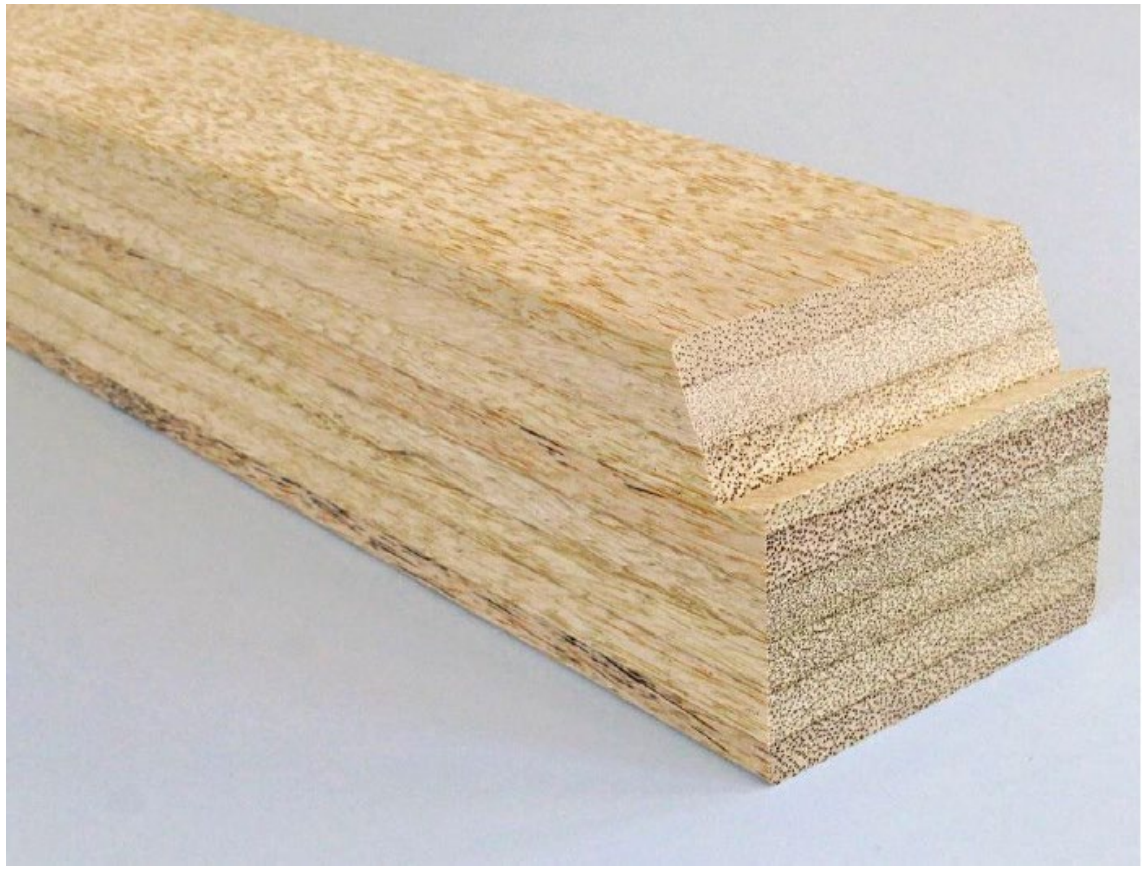
Design question

Research question

Design criteria III: Buildable with local construction workers

Design proposal

Image source: Homag



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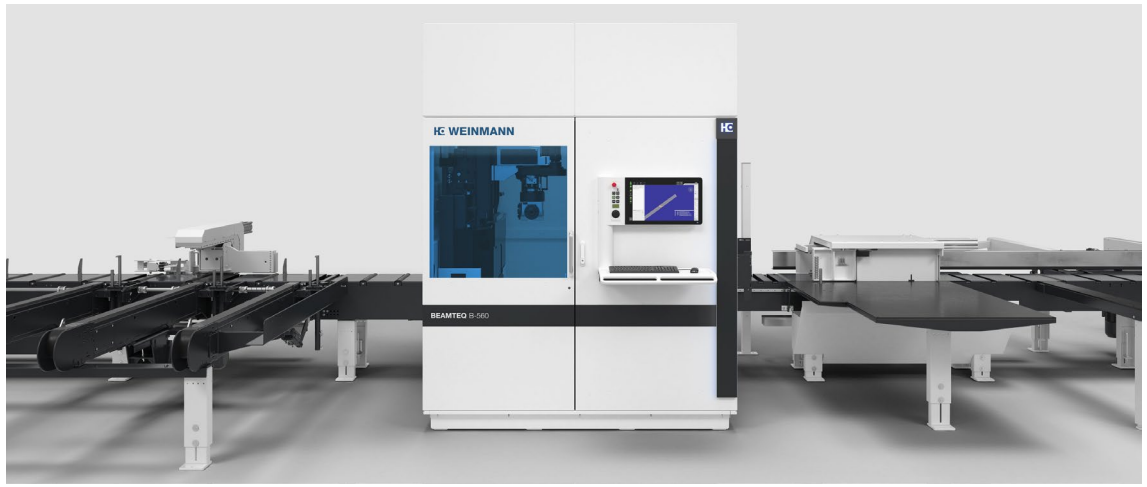

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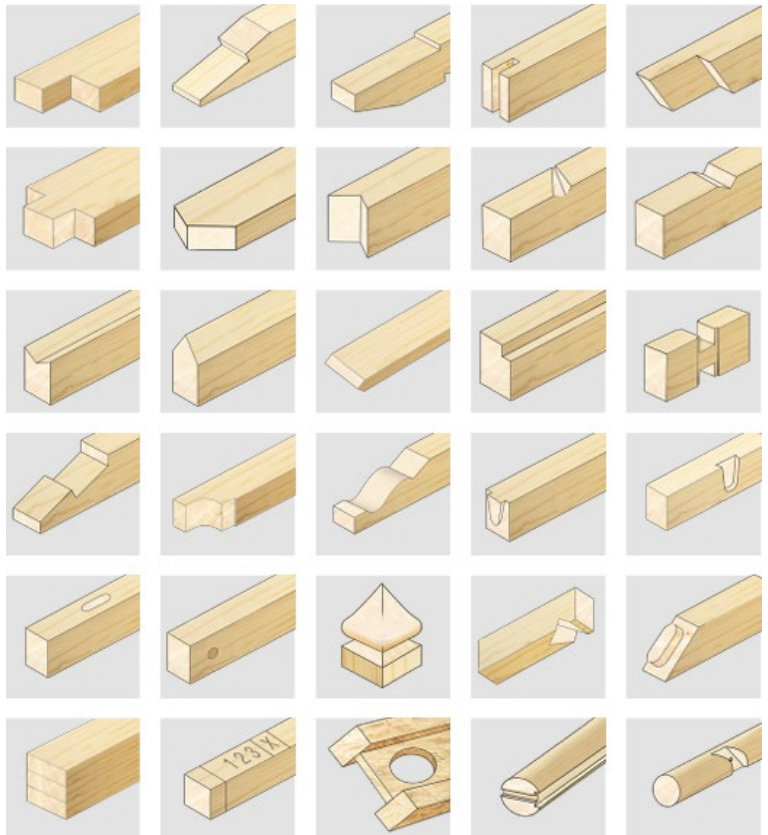


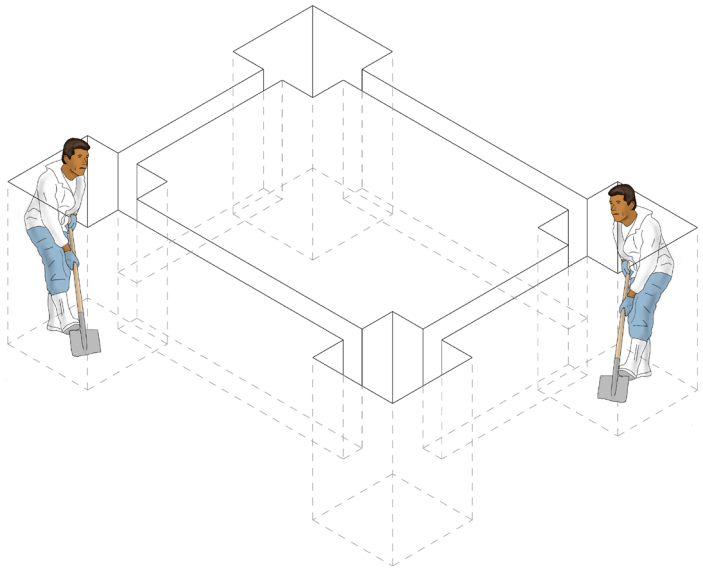
No cranes

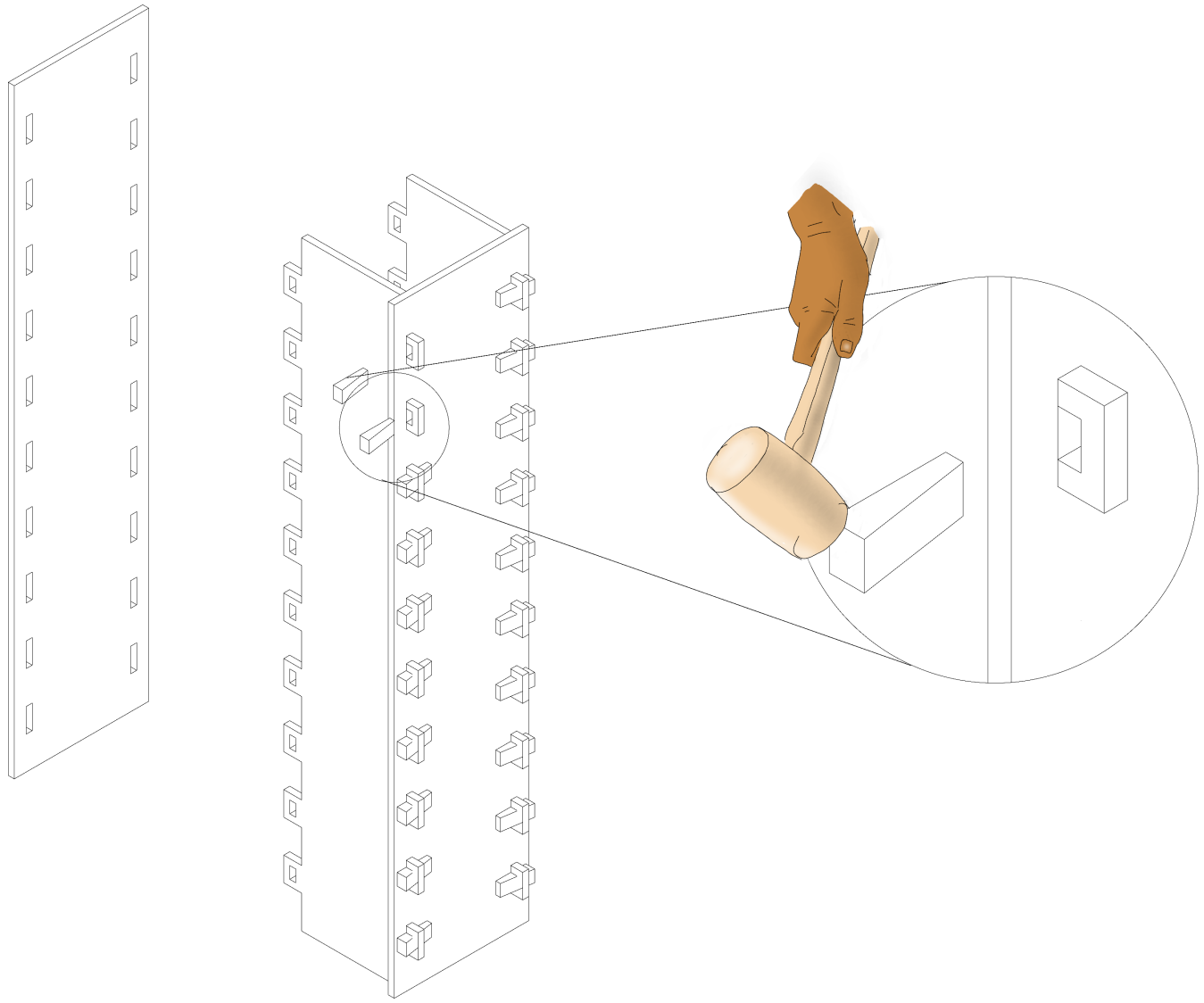
50 < Kg

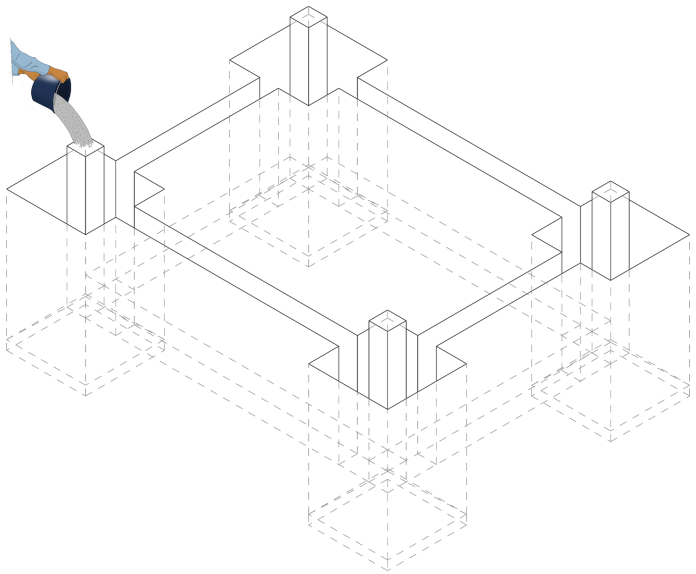
Experiences with concrete

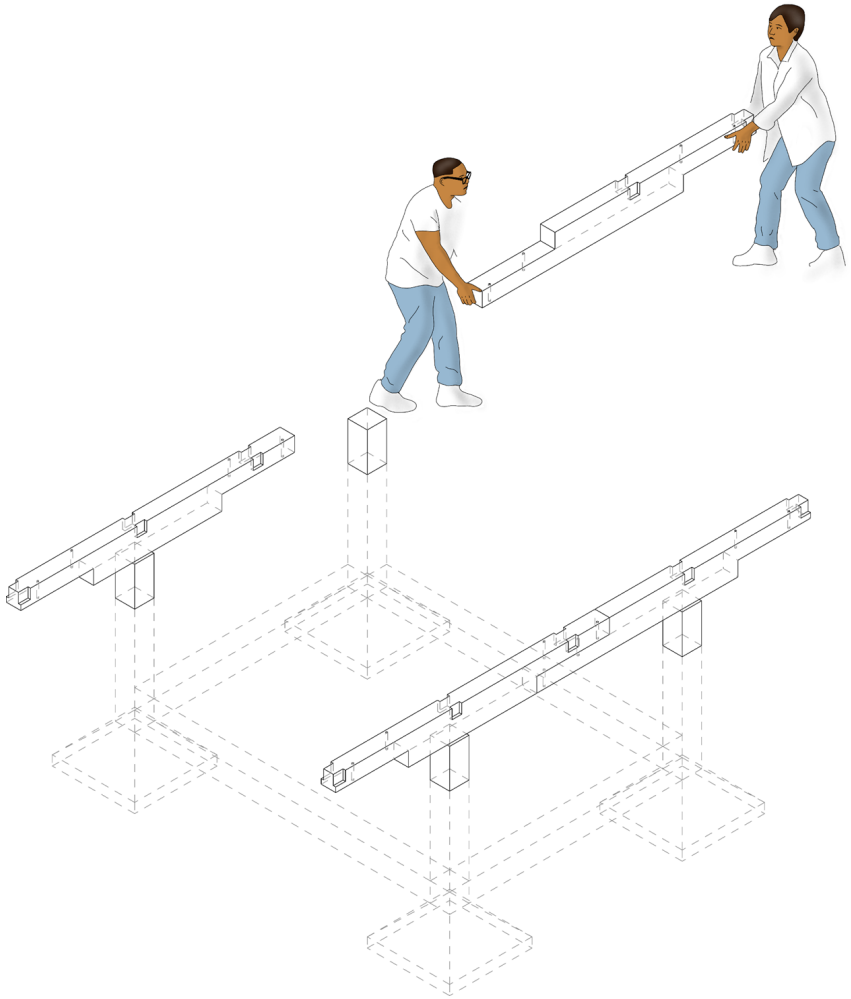
Max beam: 450mm x 200mm

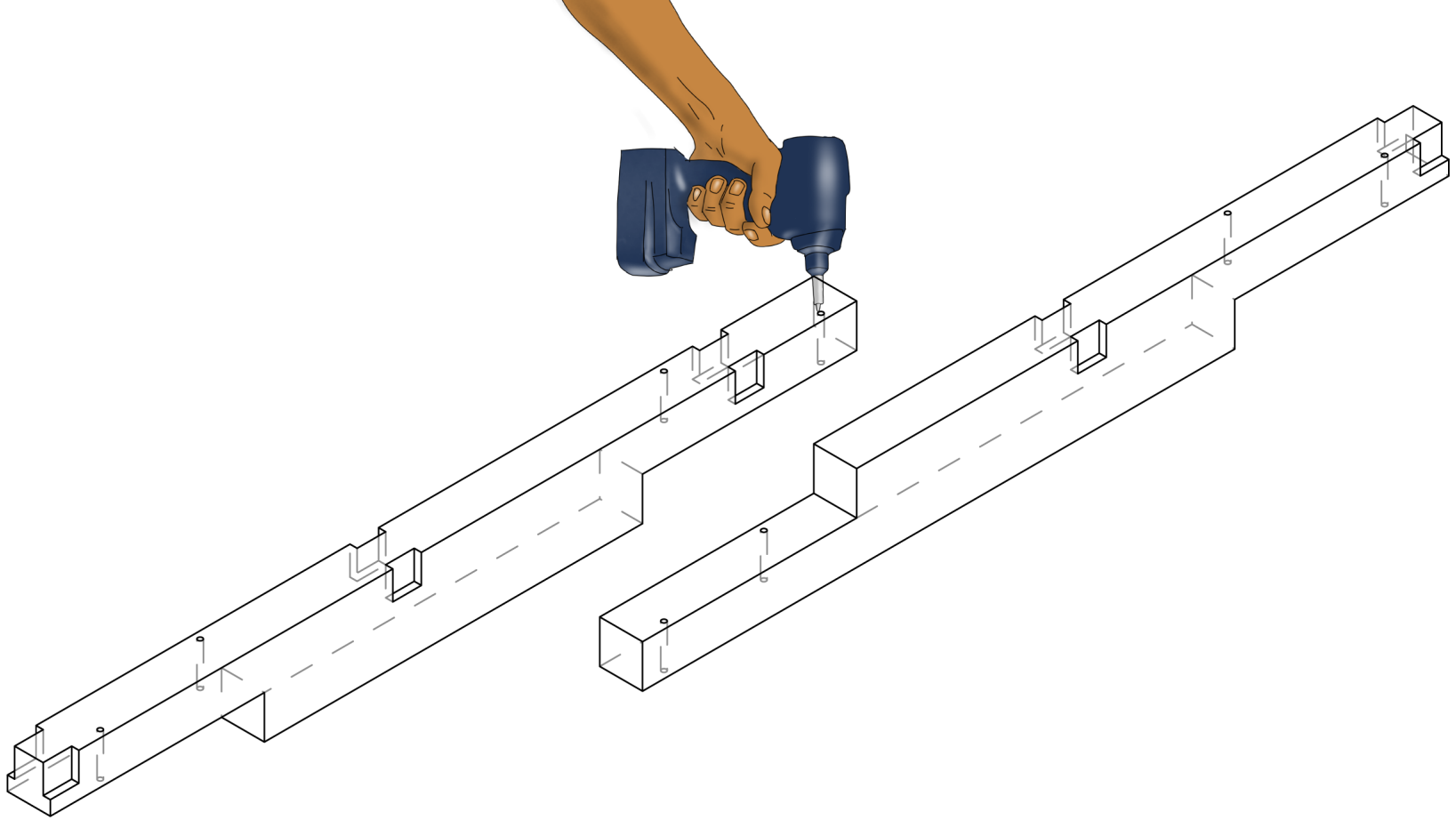
Max blockboard: 450mm x 20mm

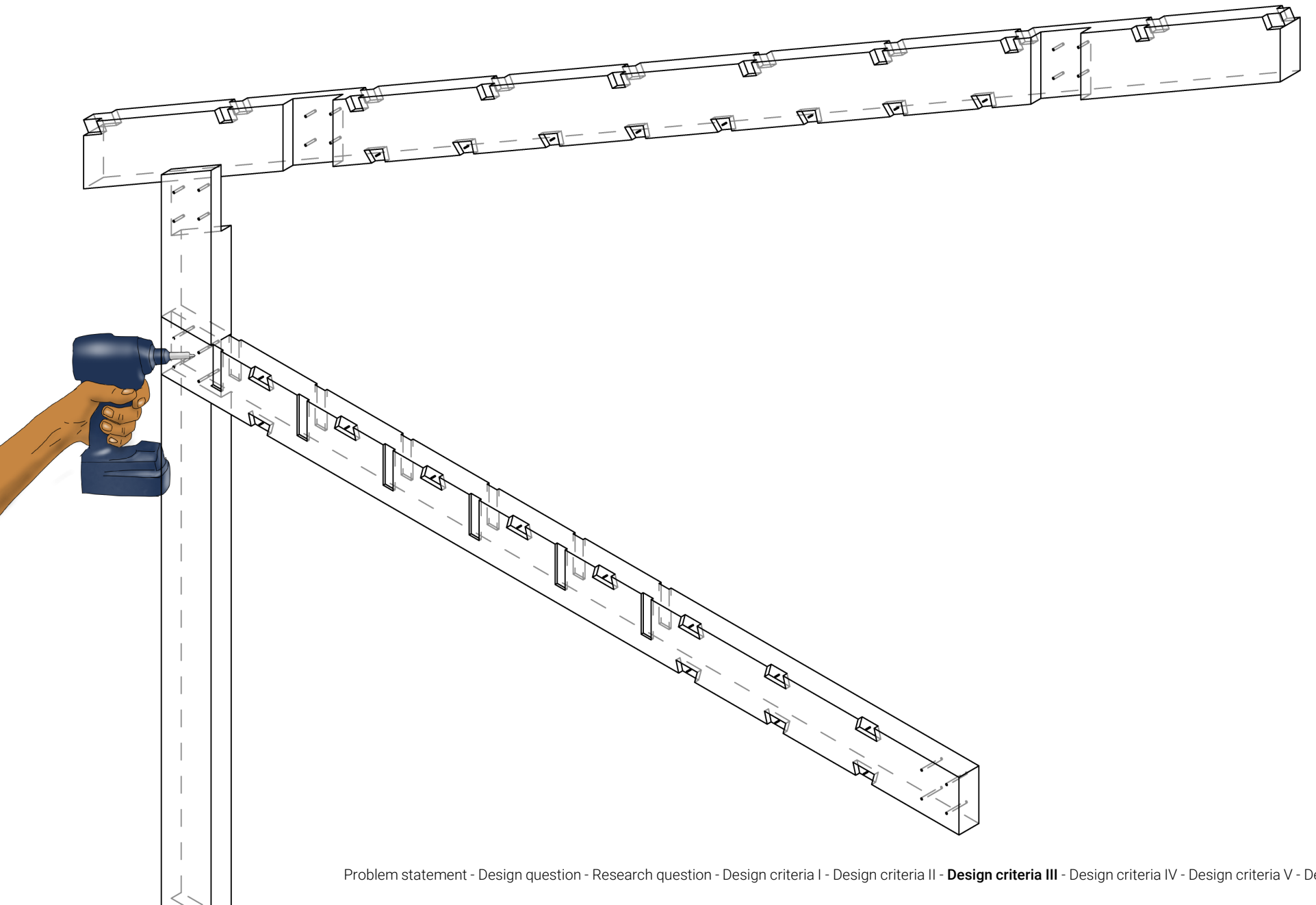


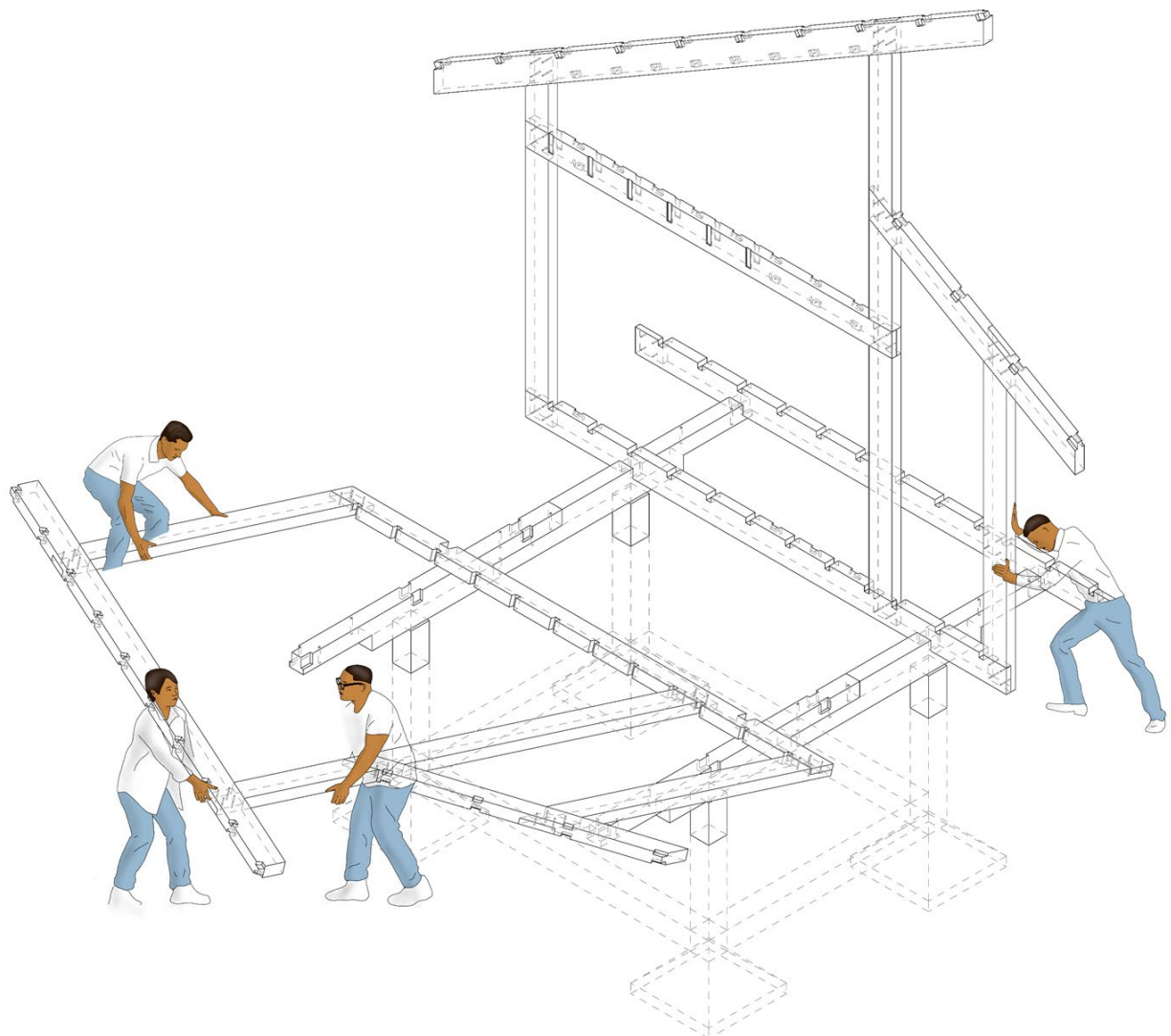


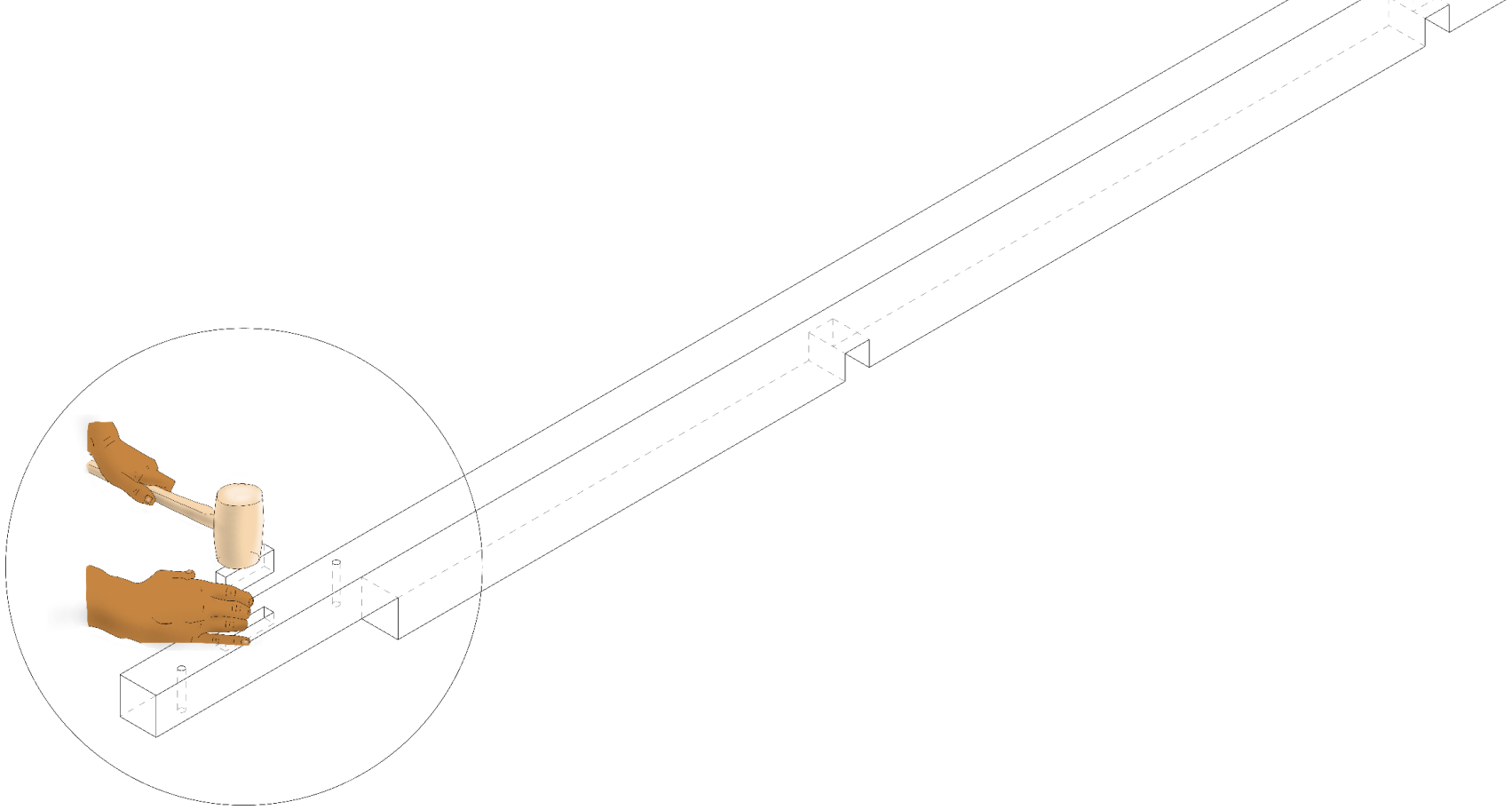


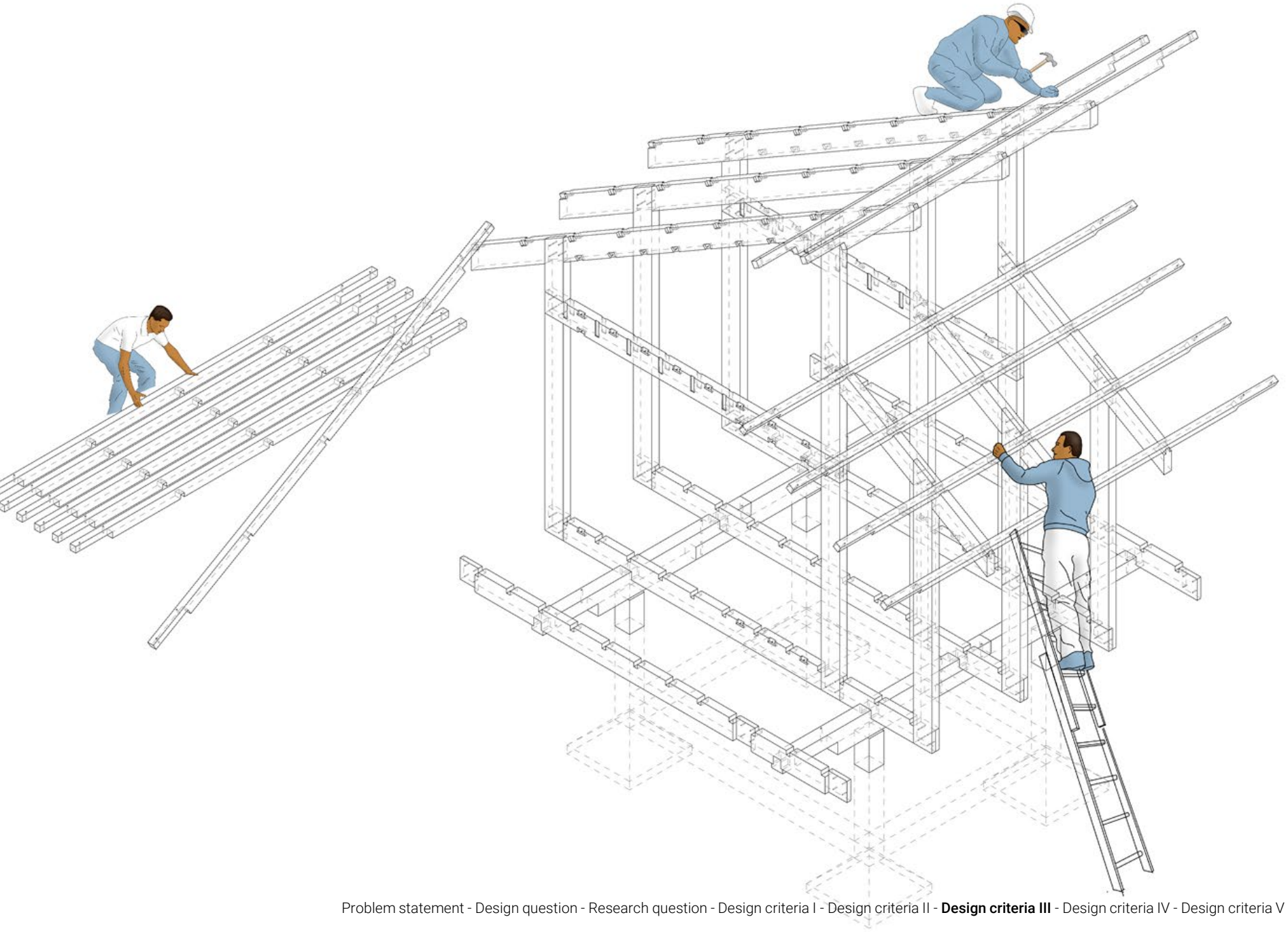


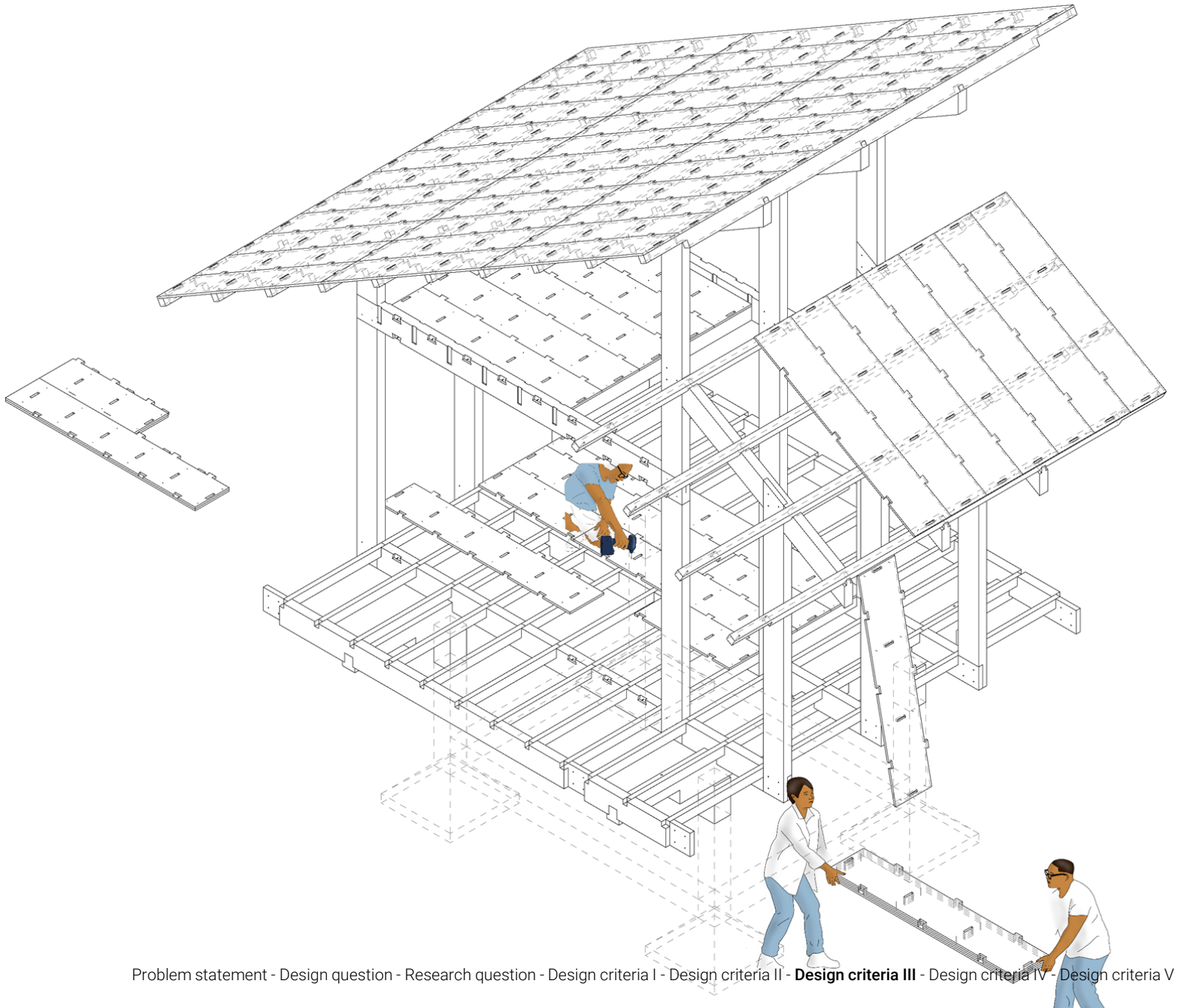


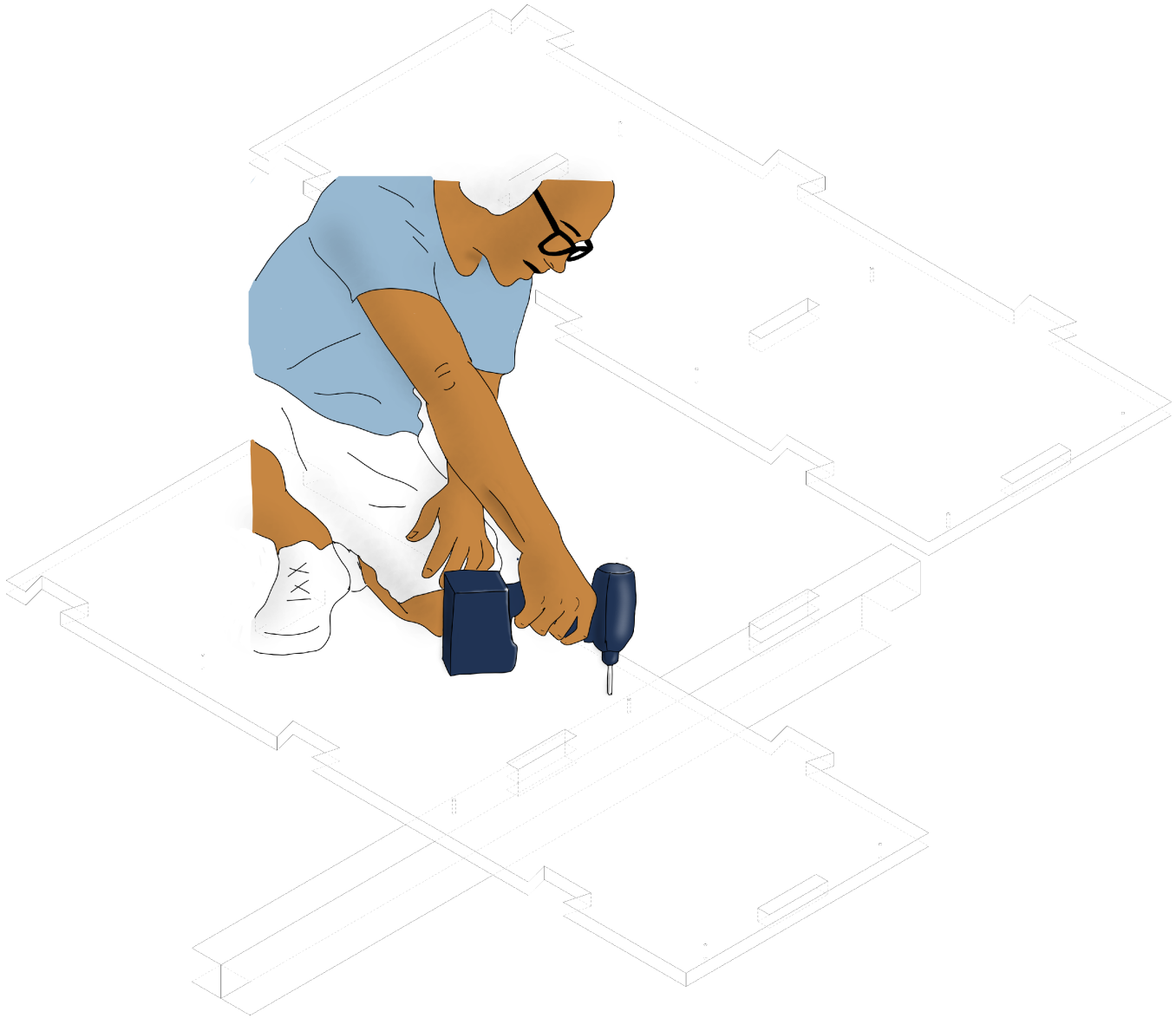


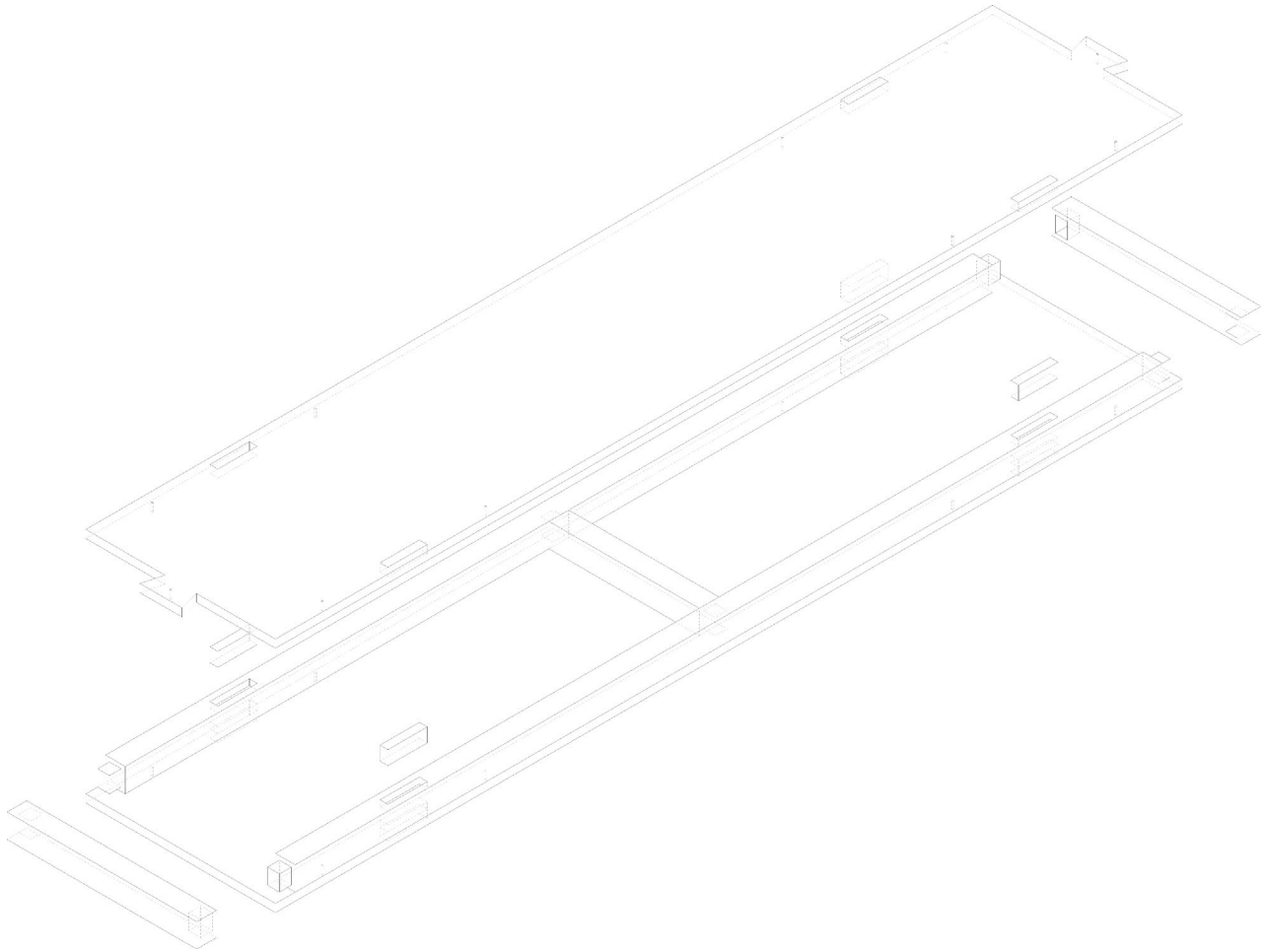


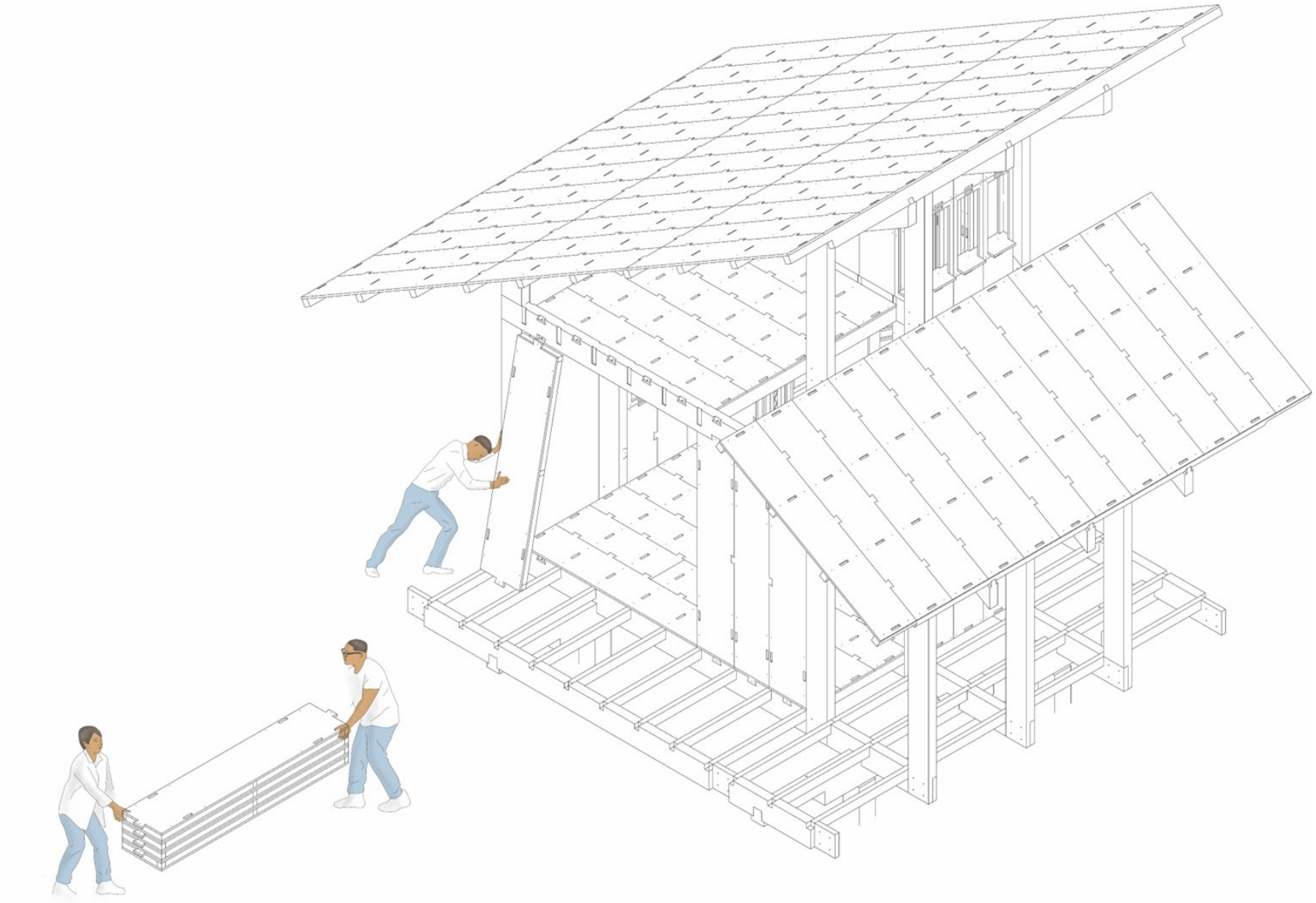


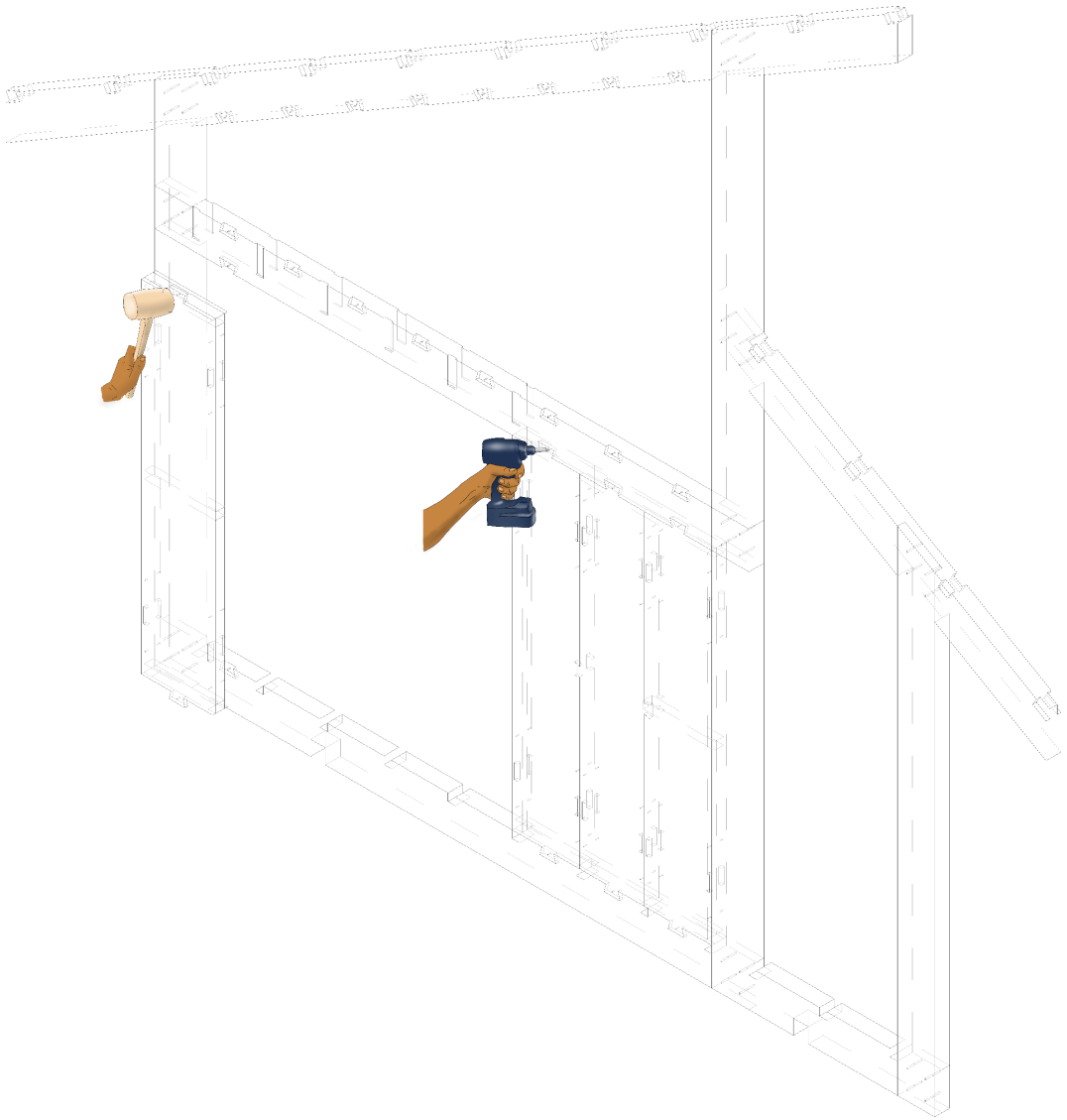


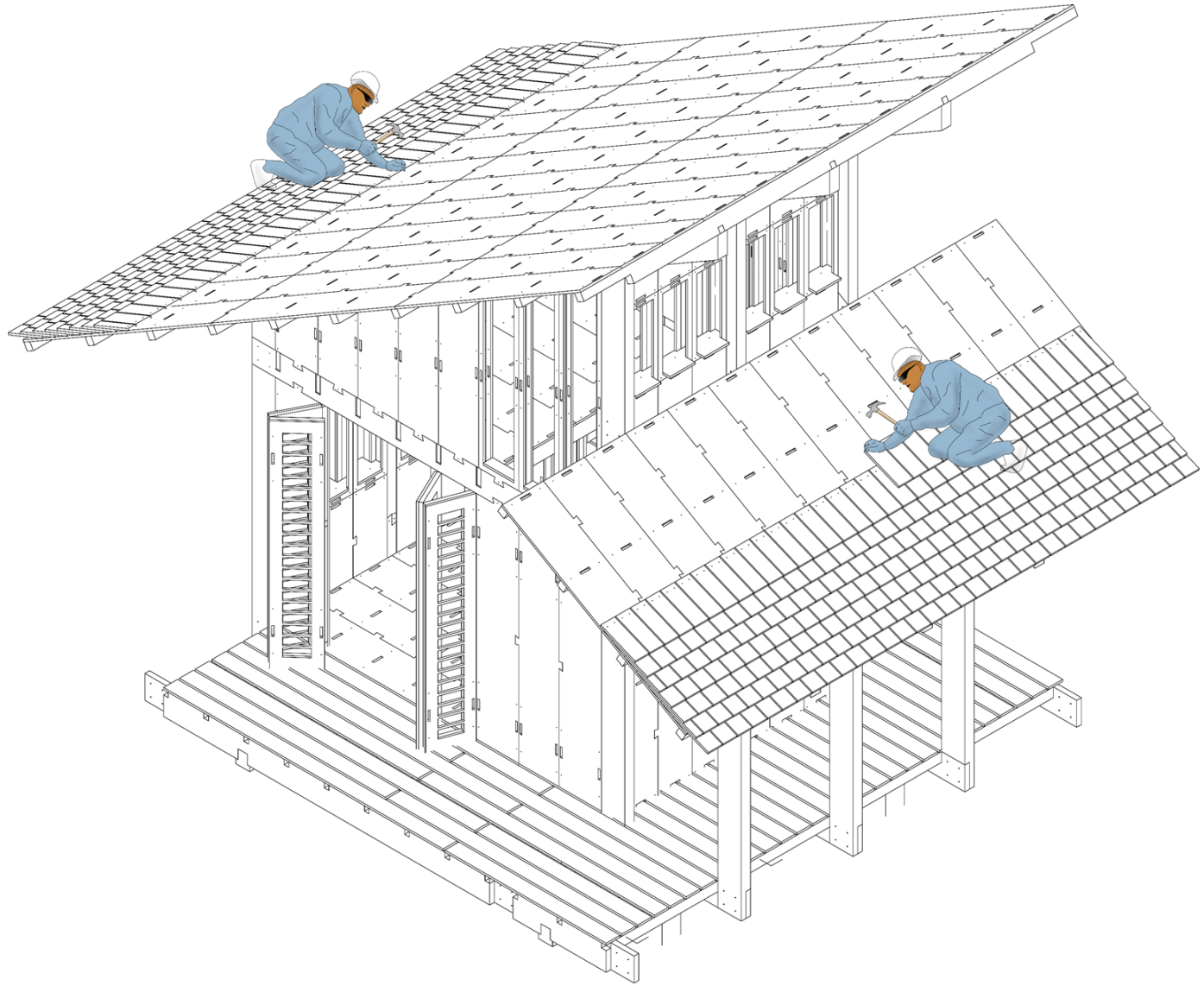


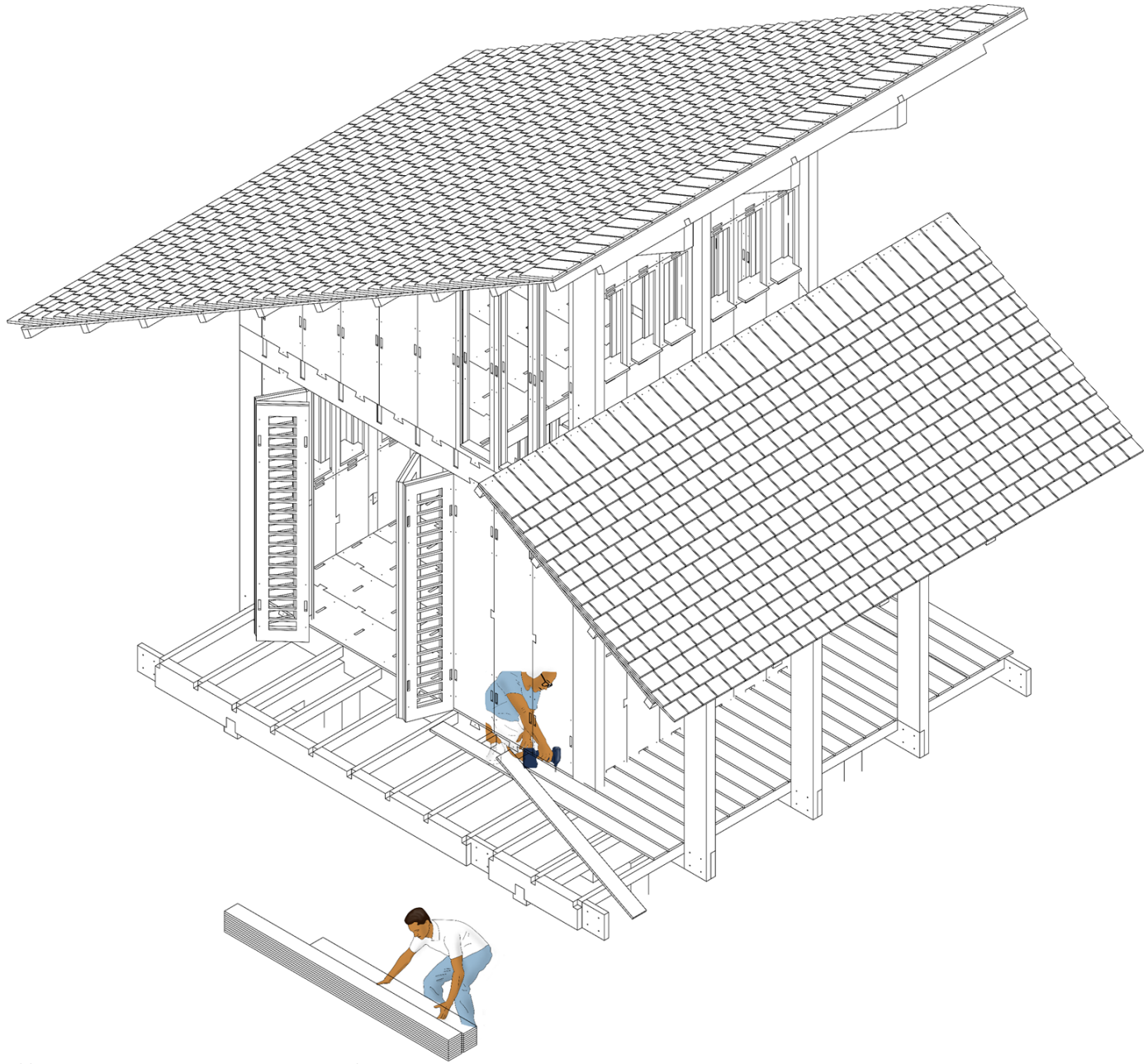












Problem statement

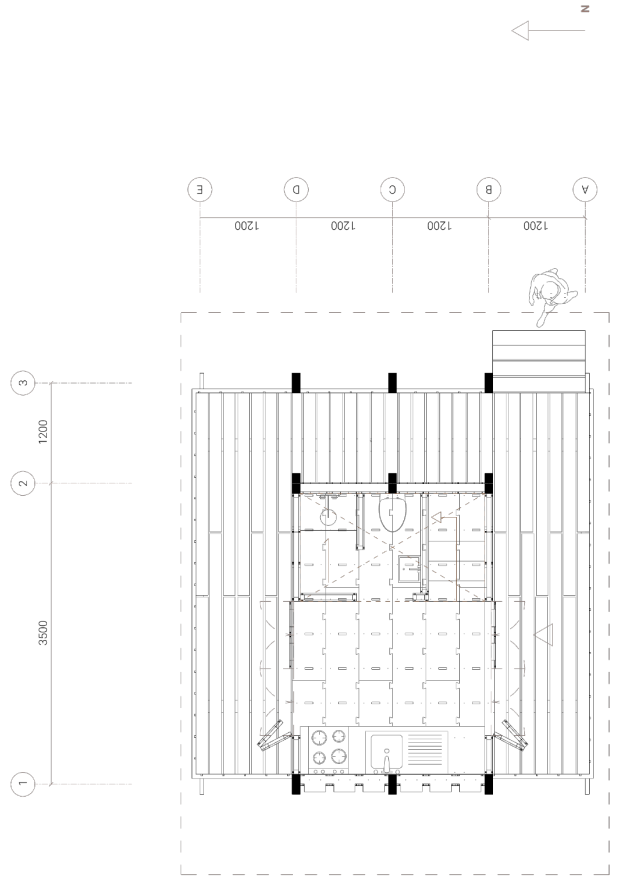
Design question

Research question

Design criteria IV: Accessible for low-income people

Design proposal

Problem statement - Design question - Research question - Design criteria I - Design criteria II - Design criteria III - **Design criteria IV** - Design criteria V - Design proposal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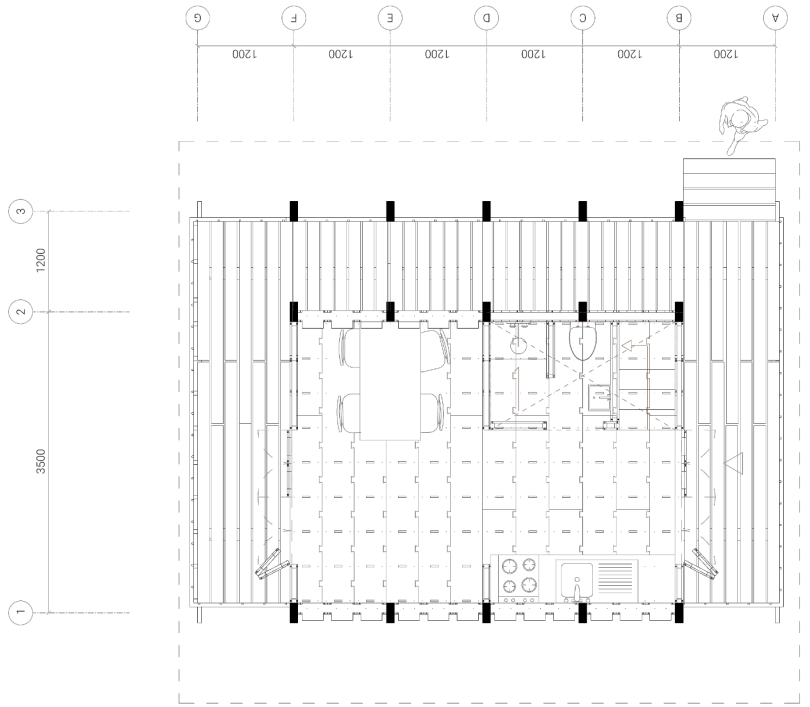
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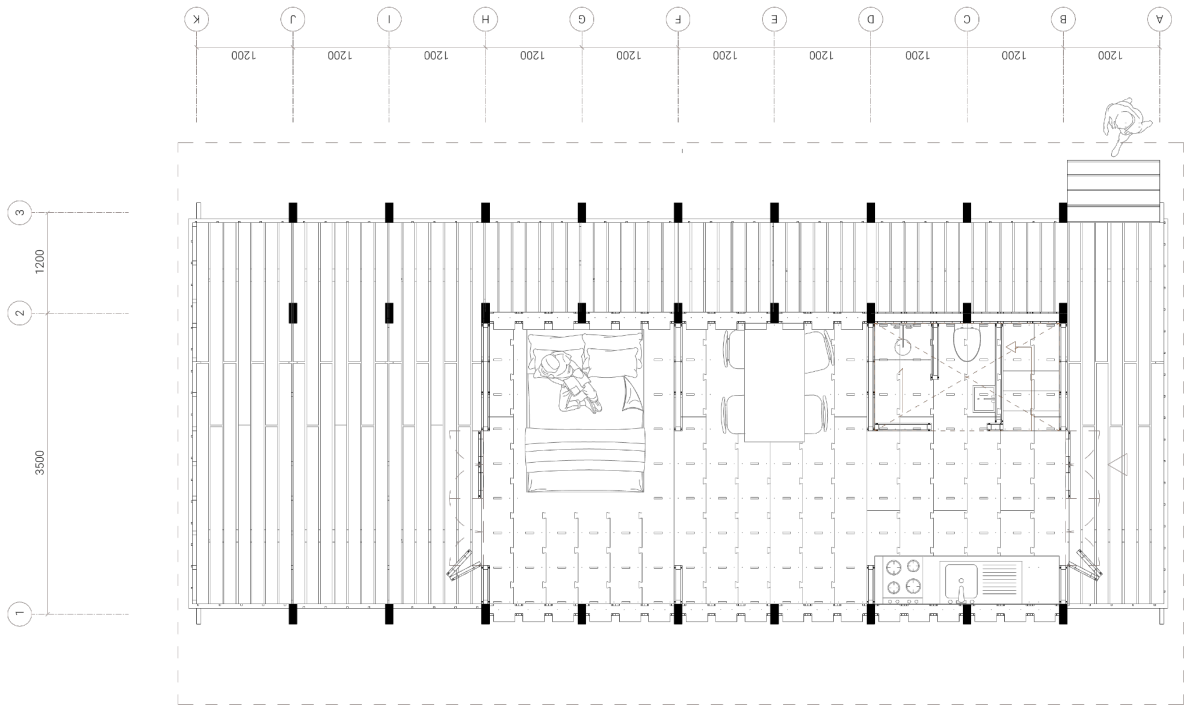
Problem statement - Design question - Research question - Design criteria I - Design criteria II - Design criteria III - **Design criteria IV** - Design criteria V - Design proposal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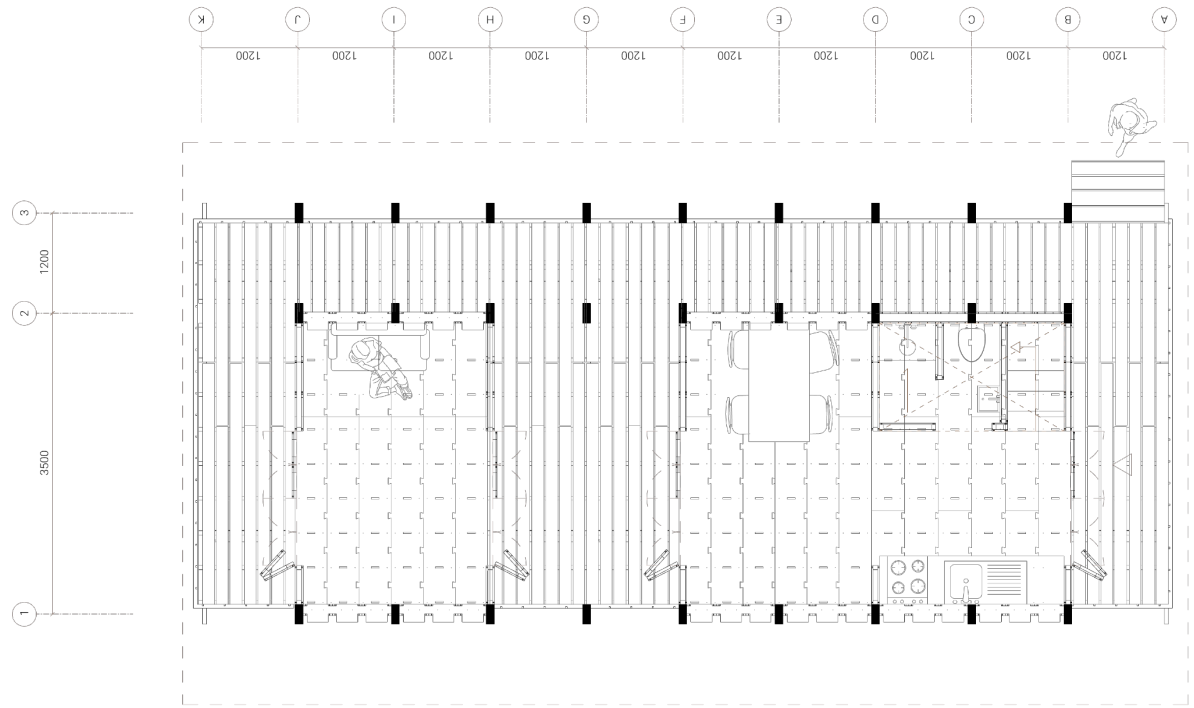
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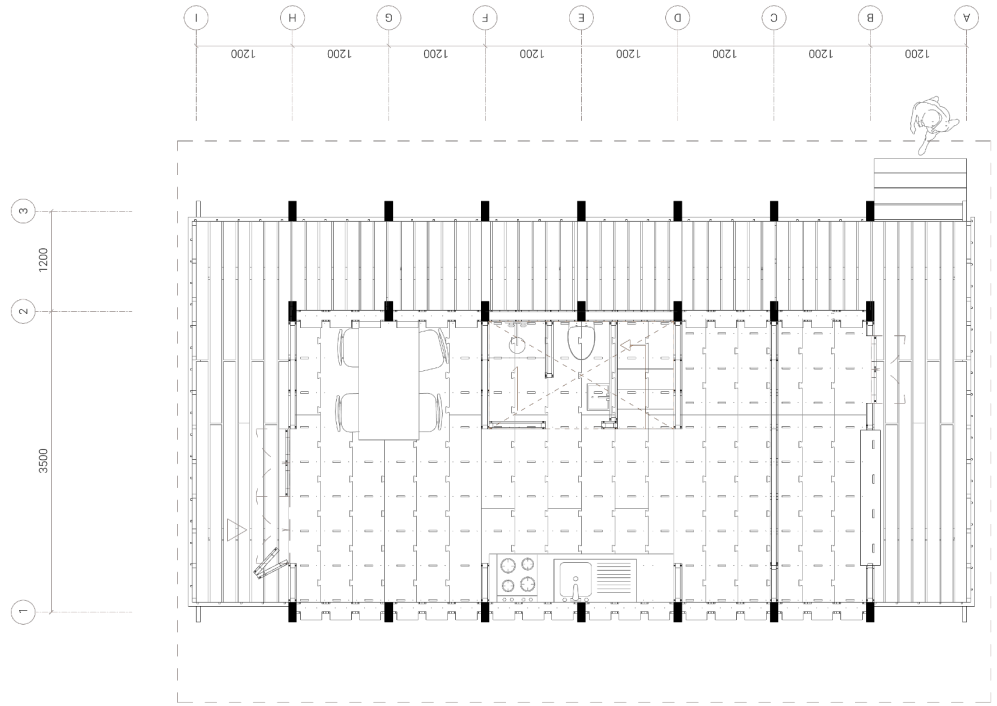
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Problem statement

Design question

Research question

Design criteria V: Building system that can be implemented throughout tropical climate region

Design proposal


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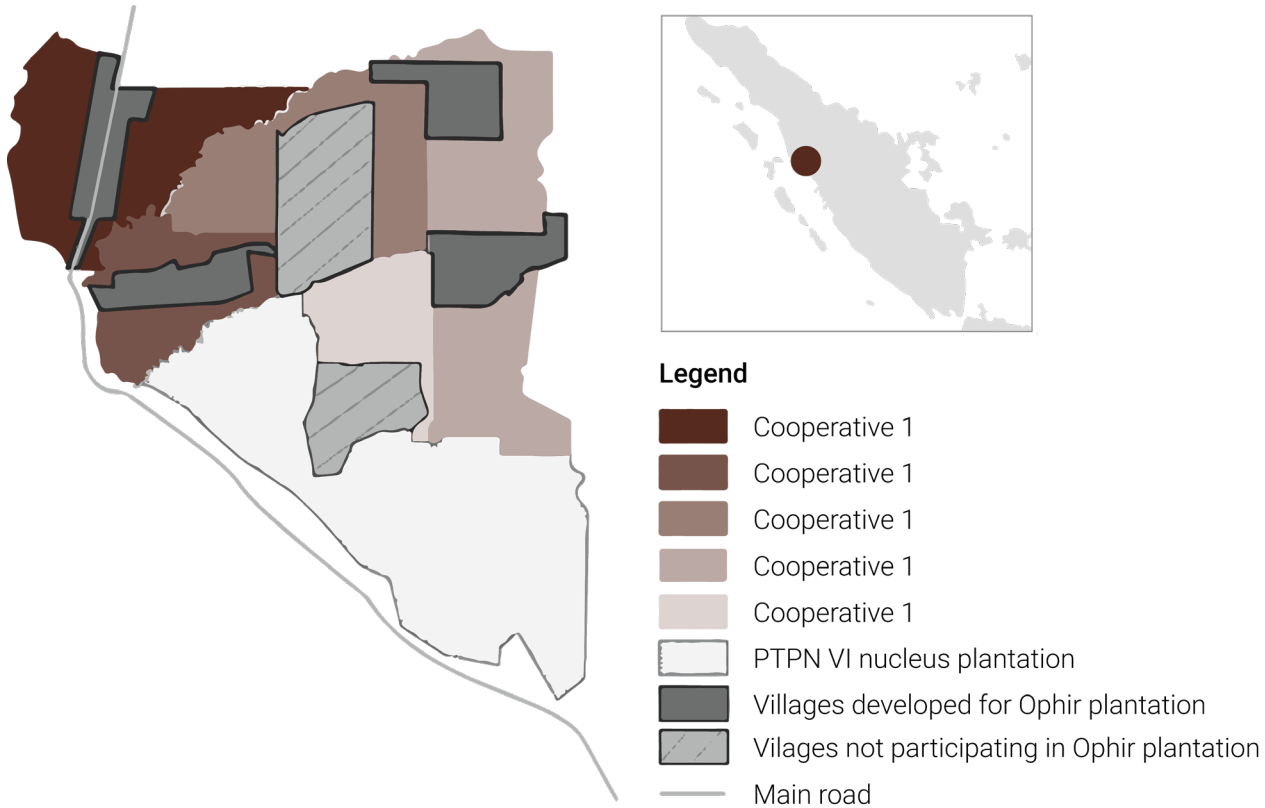
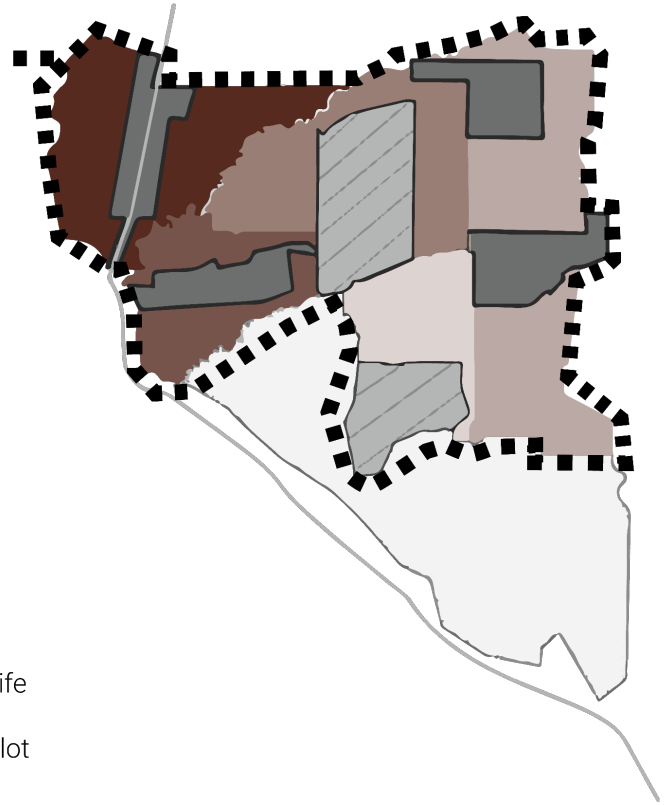

Legend
Cooperative 1
Cooperative 1
Cooperative 1
Cooperative 1
Cooperative 1
PTPN VI nucleus plantation
Villages developed for Ophir plantation
Vilages not participating in Ophir plantation
Main road

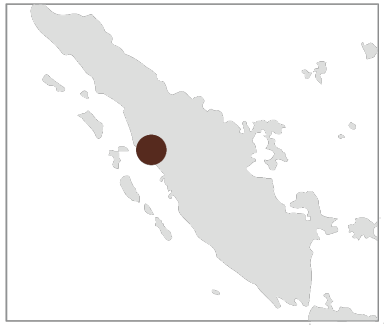
Supra-Cooperative
5 Cooperatives
4800 ha plantation
3100 Biobased housing kits

Cooperative
20 groups per cooperative
1000 ha plantation

Group
25 families per group
50 ha plantation

Farmer
Husband & wife
2 ha plot
0.5 ha homeplot





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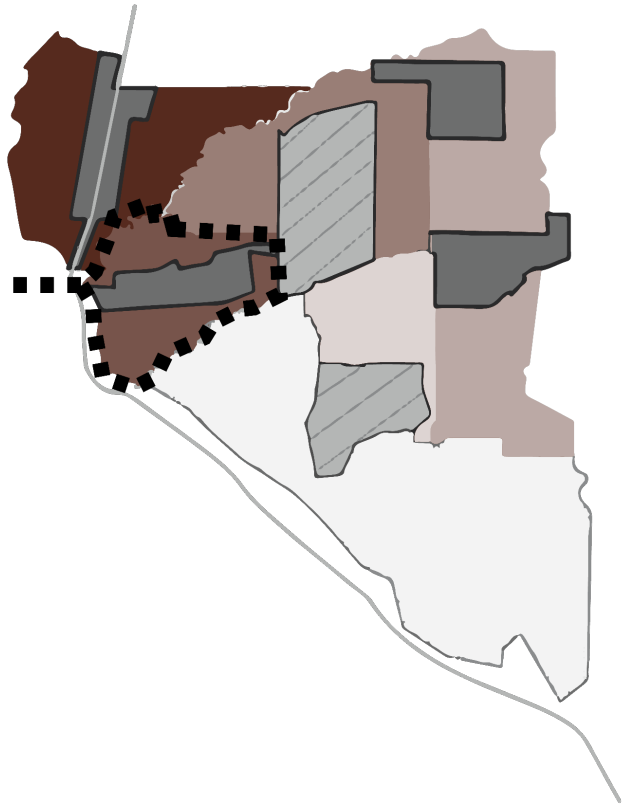

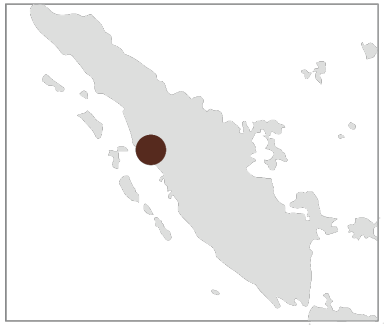

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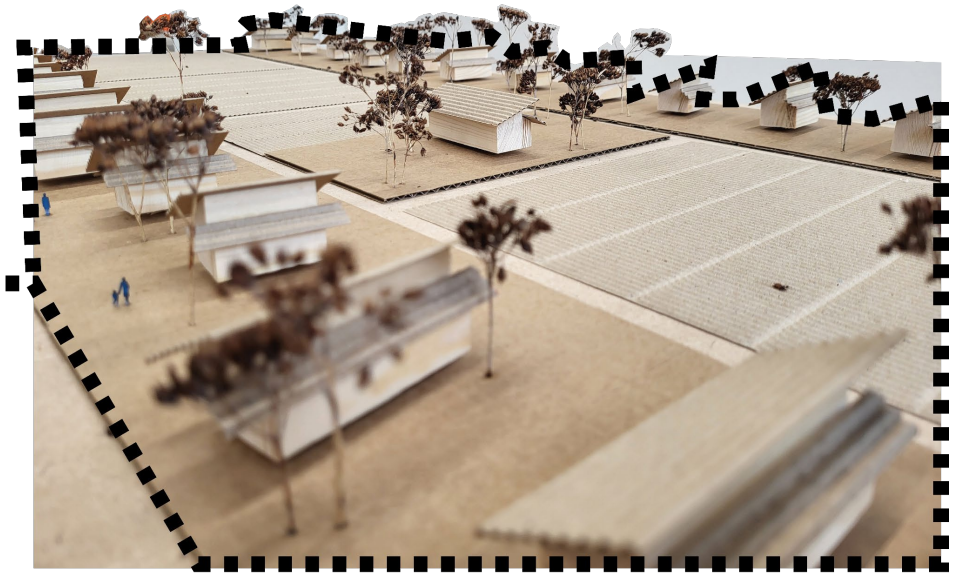

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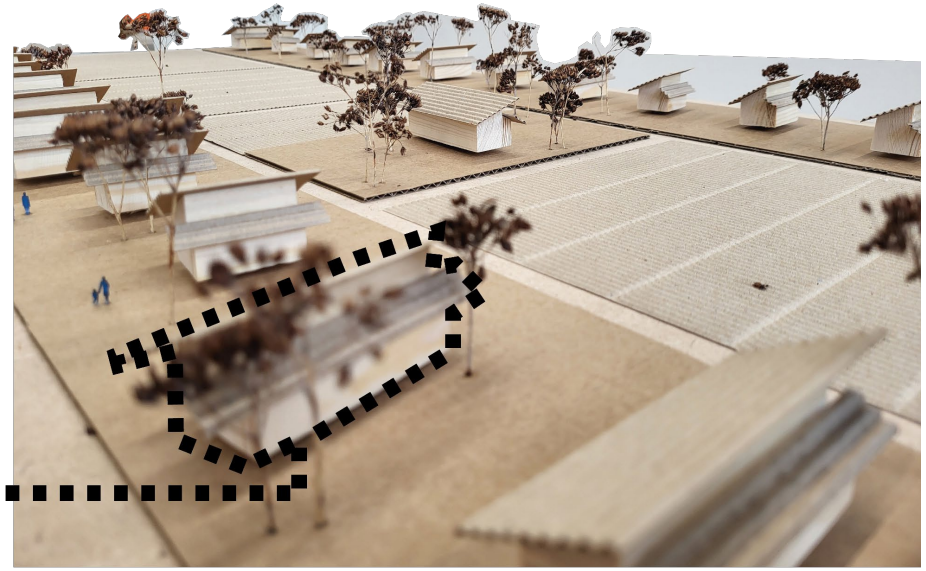

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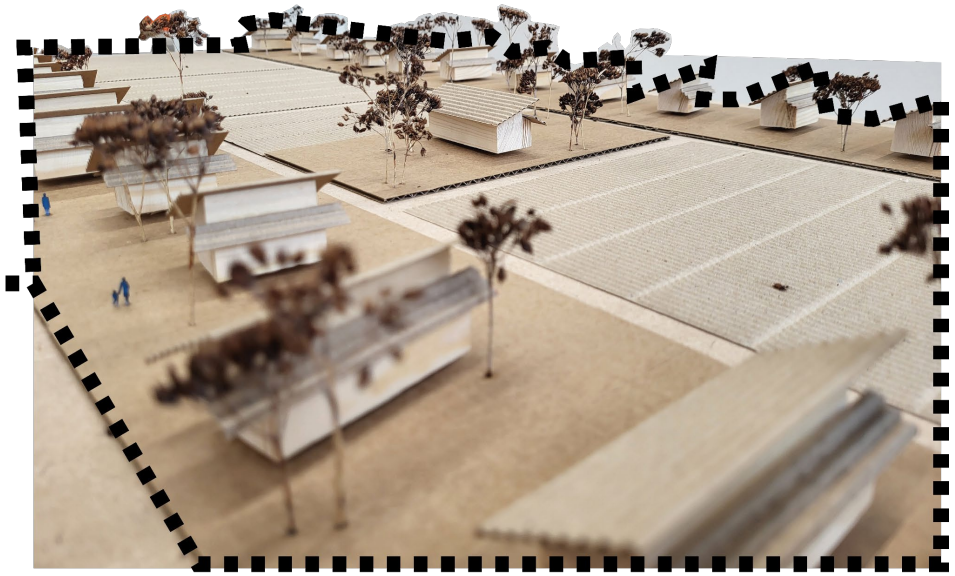

Energy usage: 25 households x 900 kWh/year = **22,500 kWh/year**

Solar radiation: **1,825 kWh/m^2/year**

Conversion rate solar panel: **20%**

Energy per m2 solar panel: 0.2 x 1,825 kWh/m^2/year = **365 kWh/m^2/year.**

Amount of m2 needed: 22,500 kWh/year ÷ 365 kWh/m^2/year ≈ **61.64 m^2.**

Total square meters of vegetable garden: **8536 square meters**

Square meters of vegetable garden per household: **341,5 square meters**

Rule of thumb for watering vegetable garden is: **2.36 liters per square meter.**

8536 square meters x 2.36 liters/square meter = **20,124.96 liters per week**

In both Indonesia and the Netherlands, the water usage was reported as **130 liters per person per day**

3 people per household, then the number of people will be 25 households x 3 people/household = **75 people**

75 people x 130 liters/person/day = **9,750 liters.**

a water tank that can hold 3 days x 9,750 liters/day = **29,250 liters.**

Image source: Smallholder Oil Palm Production Systems in Indonesia:

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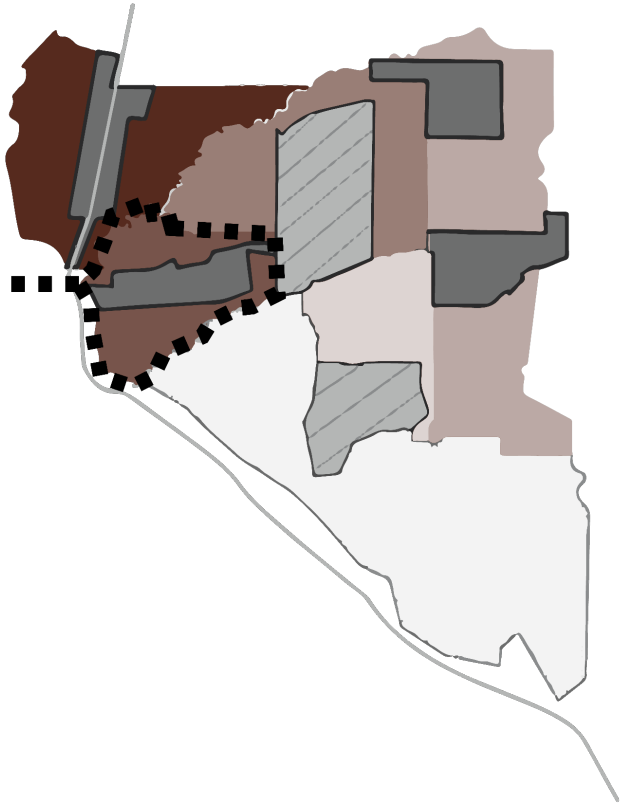

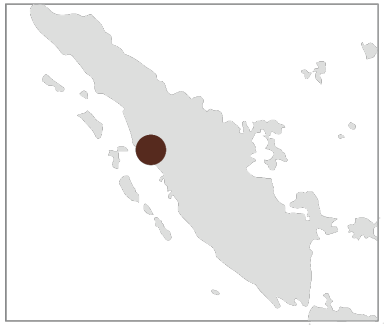

Legend

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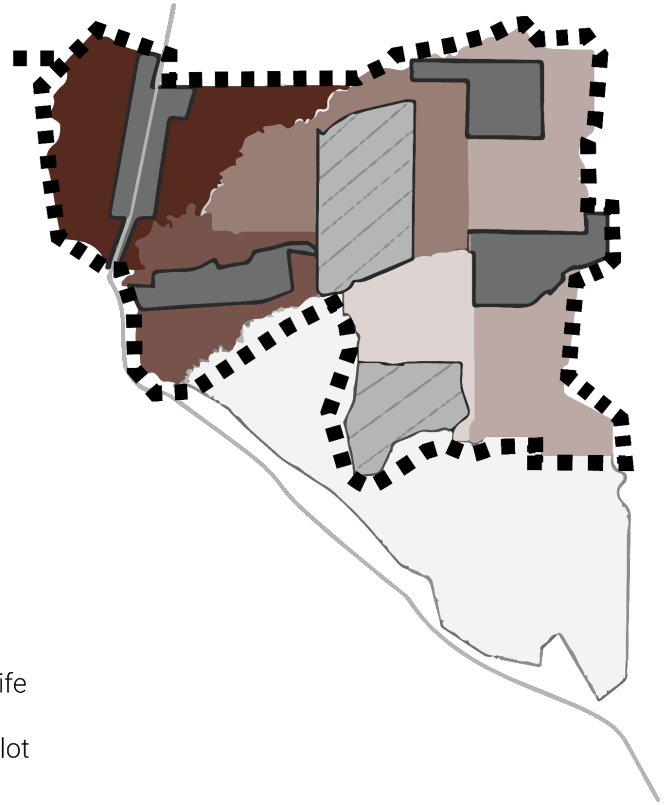

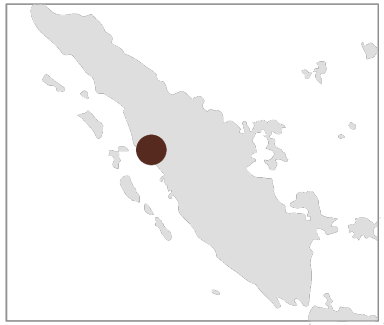

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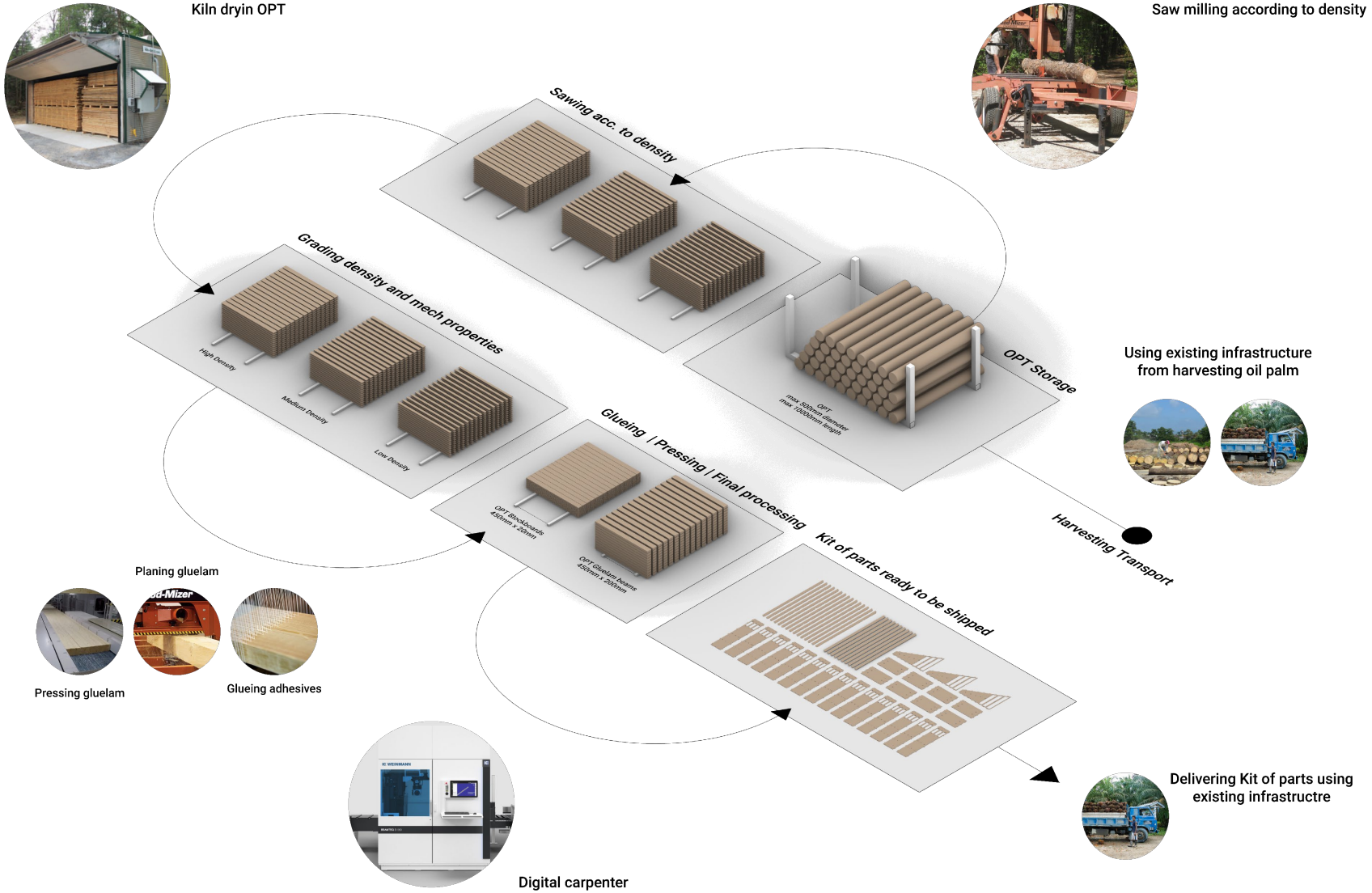
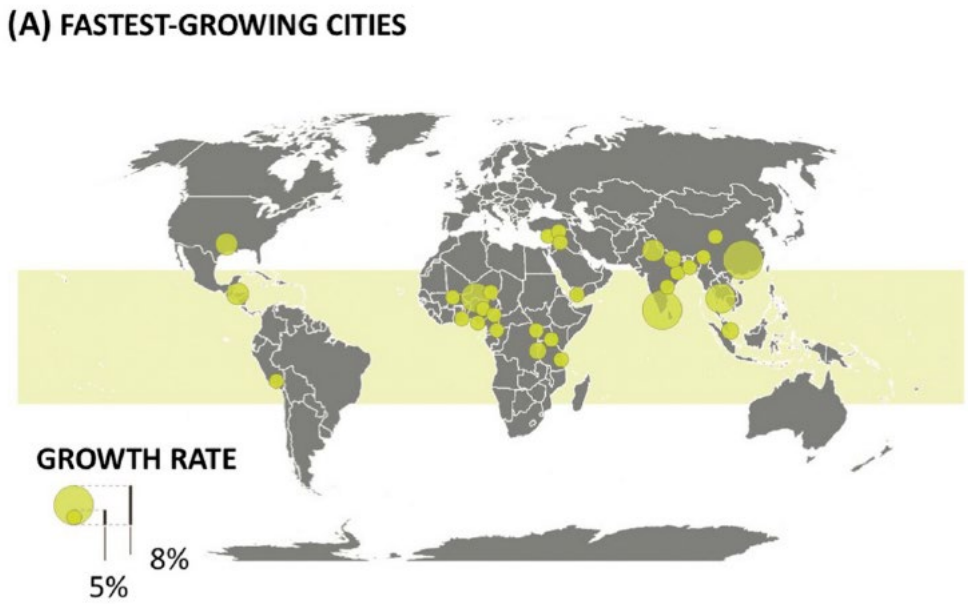


Image source: Indoor thermal comfort review: The tropics as the next frontier:



Tropical climate (A) Köppen climate classification

Tropical rainforest climate (Af),
Tropical monsoon climate (Am),
Tropical savanna climate (Dry summer: As, dry winter: Aw)

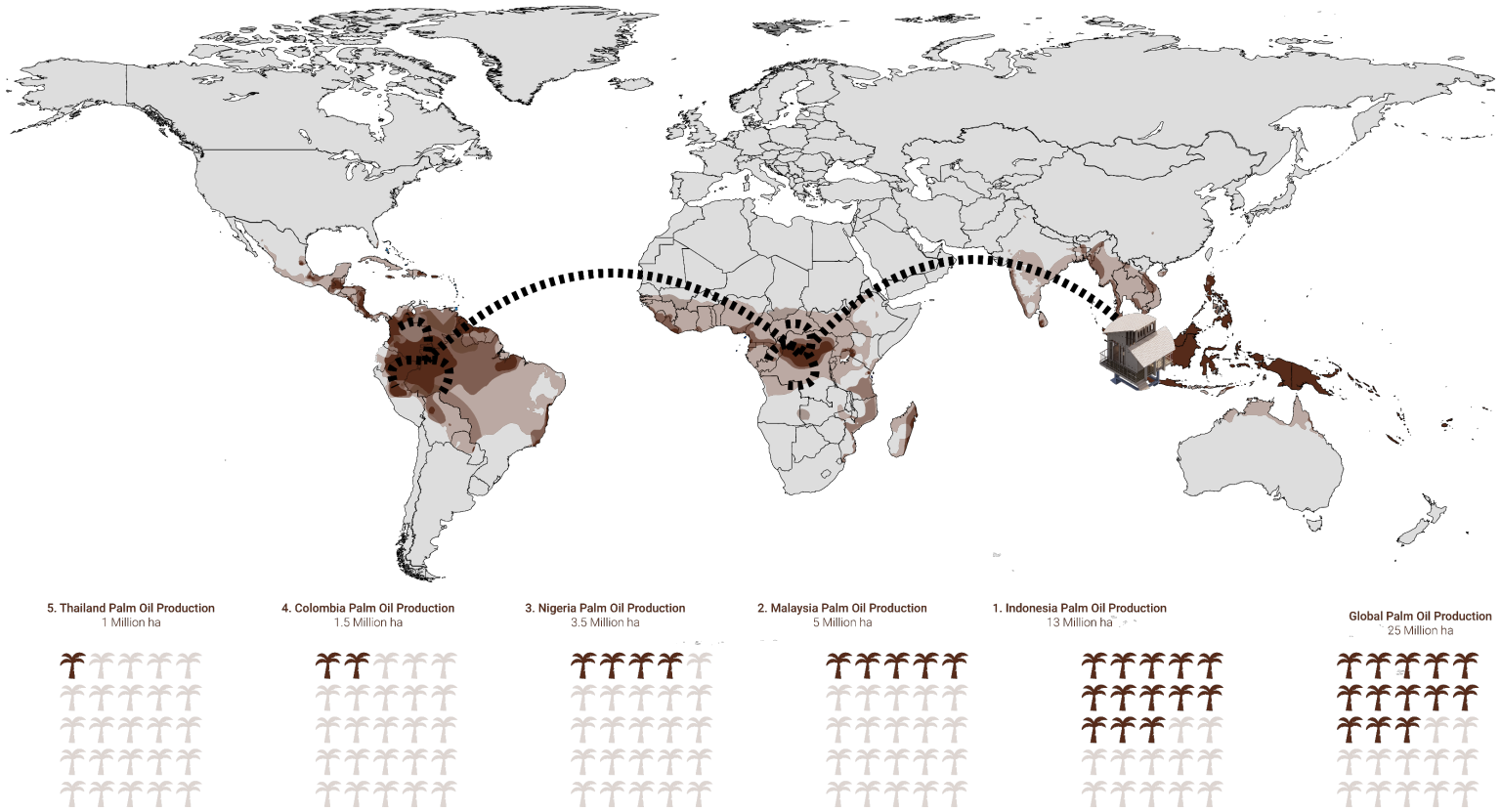
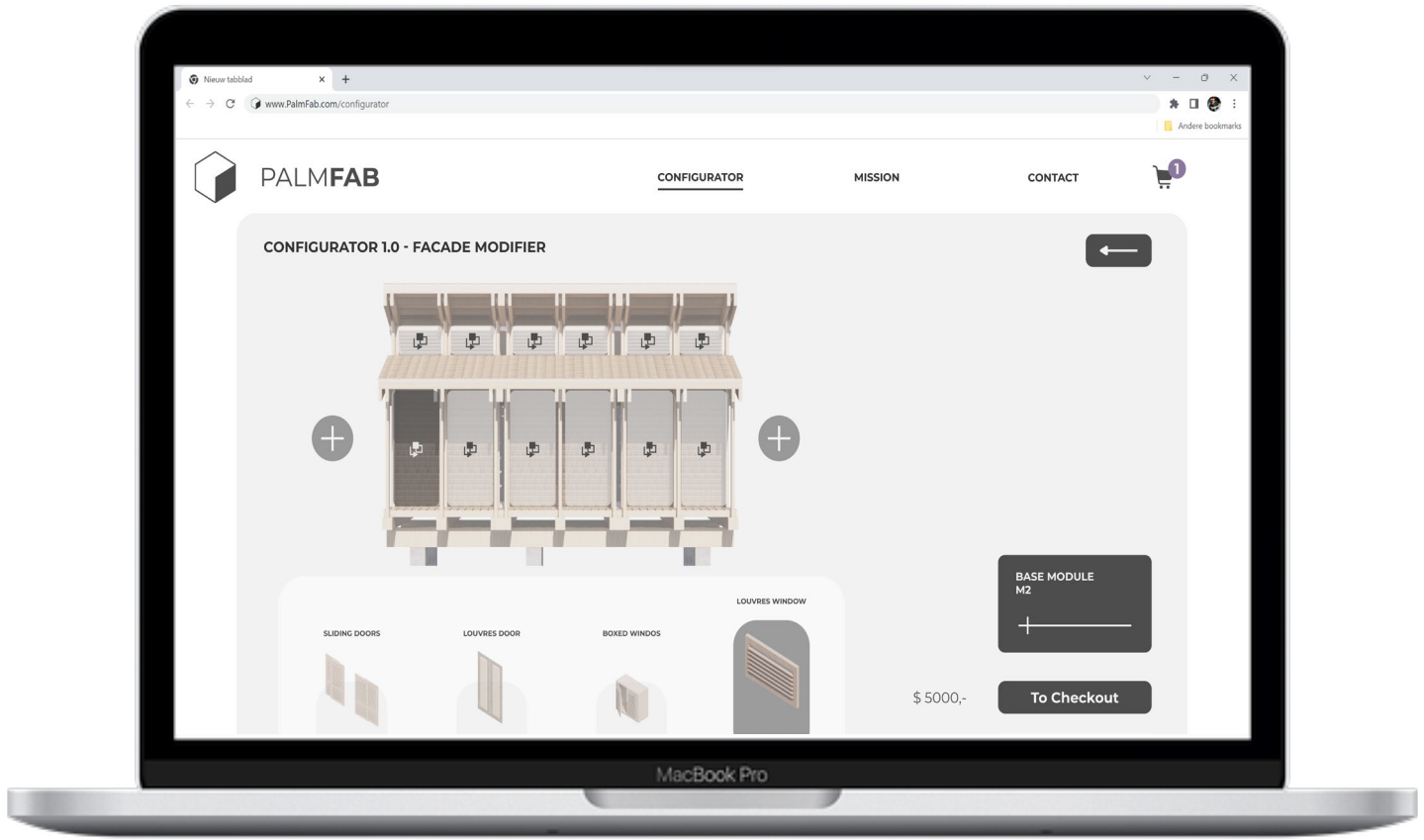


Image source: own illustration

Thank you

Questions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www.PalmFab.com/configurator
Andere bookmarks
PALMFAB
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MISSION
CONTACT
CONFIGURATOR 1.0 - FACADE MODIFIER
SLIDING DOORS
LOUVRES DOOR
BOXED WINDOS
LOUVRES WINDOW
BASE MODULE
M2
$ 5000,-
To Checkout
MacBook Pro