

a home grown (old).

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master thesis
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how can an *adaptive housing (building) system* be designed to *accommodate the changing spatial needs* of its residents, while *incorporating co-living principles*?

reader's guide.

This research aims to use the 'research by design' methodology to find a possible solution to the current housing crisis. The report first defines the problem within the housing crisis that aims to be investigated, and where the focus, within this bigger issue, lies ('what?'). After analysing the problem, its relevance, and the scope of the research ('why?'), the report goes on to define the approach that will be used to find a possible solution for this issue ('how?'). The approach will be described according to the existing theoretical framework and based on what 'gaps' within that framework have not yet been explored. After that, within the results section, prototypes based on literature reviews & case studies will be performed. By exploring different design iterations, the report gathers design principles that are then synergised into a coherent design proposal. This design aims to provide an applied solution as to how to use architectural design elements to address the housing crisis and its related social issues.

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introduction.

With an ever-rising global population, it doesn't seem strange to expect there to be a housing shortage. Especially in Europe, due to the influx of immigration and the low rates of construction, there is a huge housing shortage which has led to a housing crisis (European Parliament, 2024). The Netherlands is a prime example to illustrate this issue.

problem statement.

The Netherlands has been struggling with a housing shortage for as long as we can remember, but ever since the crisis in 2008, the issue hasn't stopped growing (Geld of je Leven & NPO Radio 1, 2023). Even though policymakers have developed different strategies in recent years, it has taken until last year for the housing shortage to actually start decreasing in size as opposed to increasing (NOS Nieuws, 2024 & 2025).

According to the Ministry of Housing and Spatial Planning (Ministerie van Algemene Zaken, 2023), there are several reasons for this. Some are more *physical or policy-related*, like the lack of space, the high construction costs, and the long procedures when requesting permits, which depend on either market or policy changes. Other reasons are more *social or demographic*, like the increasing presence of single-person or smaller family households, the ageing population, and the influx of immigrants, which requires a societal (behavioural) shift in people's perceived housing needs.

The physical and policy-related issues are predetermined factors that lie outside the influence of this spatial research, due to related stakeholders (like governments, existing residents, politicians,...). Therefore, this paper will position itself in the role of the architect who, through a proposed design solution, will enlighten people to change their perceived (housing) needs.

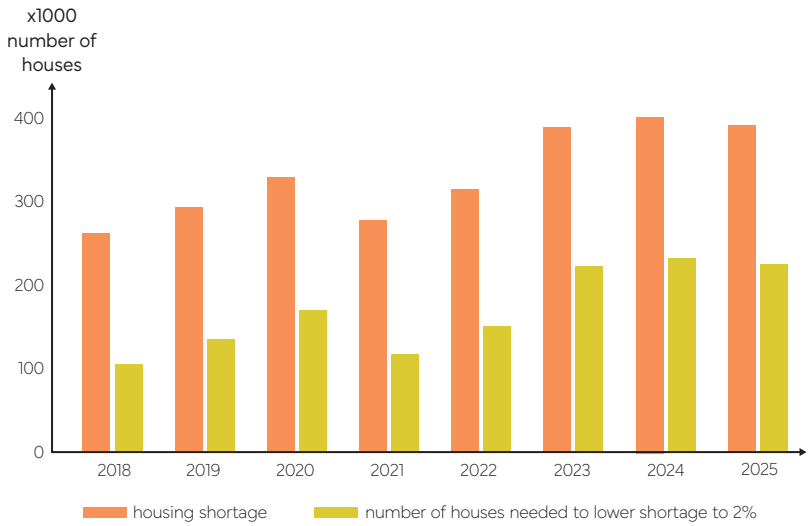

figure 1.1.

figure 1.1. *Housing shortage throughout the years. Adapted graph from ABF Research (Groenemeijer et al., 2024) & NOS Nieuws (2025).*

figure 1.2. *Causes of the housing shortage & pains it provokes. Author's work, based on researched sources (inspired by Ministerie van Algemene Zaken, 2023)*

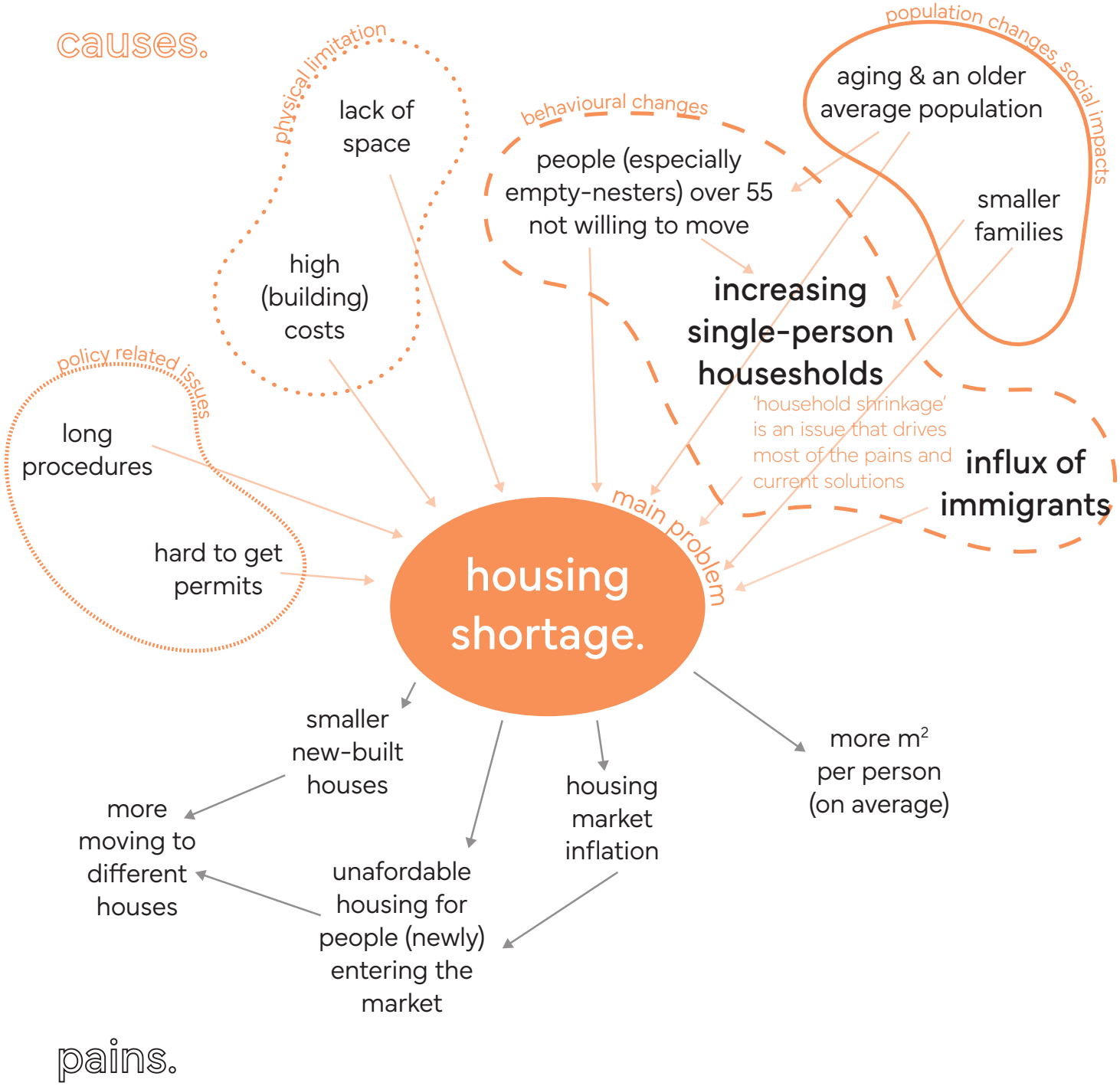
causes.
physical limitation
lack of space
high (building) costs
behavioural changes
people (especially empty-nesters) over 55 not willing to move
population changes, social impacts
aging & an older average population
smaller families
increasing single-person households
'household shrinkage' is an issue that drives most of the pains and current solutions
influx of immigrants
policy related issues
long procedures
hard to get permits
main problem
housing shortage.
smaller new-built houses
more moving to different houses
unafordable housing for people (newly) entering the market
housing market inflation
more m² per person (on average)
pains.

figure 1.2.

problem statement (cont.).

The *increasing presence of single-person households* (also known as 'household shrinkage') is one of the social reasons that has the biggest impact on deteriorating the housing crisis (Centraal Bureau Statistiek Nederland, hereafter CBS, 2025). By now, 40% of all households (within the Netherlands) are single-person households (Klaveren et al., 2021). The decrease in people per household has also led to an increase in m^2 per person, as can be seen in Figure 1.5. According to the CBS (2018), people currently live on $65m^2$ per person, as opposed to $39m^2$ in 1990, or even $16m^2$ in 1950 (Uytenhaak, 2008). People living in single-person households, on average, tend to have the biggest surface area usage per person in contrast to some "families living on $50m^2$ or even smaller' (Klaveren et al., 2021).

One of the main reasons for this increase in m^2 per person, and why there's a big disparity between families & single-person households, comes (mostly) from *people over 55* (who become empty-nesters) *not downsizing* once their kids leave the house (Fastenau, 2025; Van Der Parre, 2021). Some of the empty-nesters who look for smaller housing struggle to find something affordable that meets their needs (Fastenau, 2025). But the vast majority don't move because they don't want to leave (Kremer, 2020). Some of these reasons are outlined in Figure 1.6. *Our ageing population makes this social impact even more relevant*, since the elderly will then occupy (oversized) houses for an even longer time.

On the other hand, there's also *an influx of immigrants within the Netherlands* (Ministerie van Asiel en Migratie, 2025). The net migration has been increasing since 2005 (CBS, 2025b), with people moving to the Netherlands from both outside and inside Europe. Within the Netherlands, there are four main reasons for migration, and depending on the reason for migration, people's nationality varies:

- 26% of people migrate to find (better) work (mainly people from Poland, India, Romania, or Spain)
- 27% of people migrate for family-related reasons (mainly people from Poland, India, Turkey, or Romania)
- 17% of people migrate to study (mainly people from China, Germany, India, or Bulgaria)
- 11% of people migrate to seek asylum (mainly people from Syria, Iraq, Turkey or Eritrea)

The diversification of the Dutch population, especially in the last 20 years (CBS, 2025b), has made housing diversity not just a matter of age or household size but also one of cultural and social values. The changing perceived housing needs depend on one's household size, age and background.

figure 1.3. *Growth in single-person households. Adapted graph from Centraal Bureau Statistiek Nederland or CBS Nederland (2025)*
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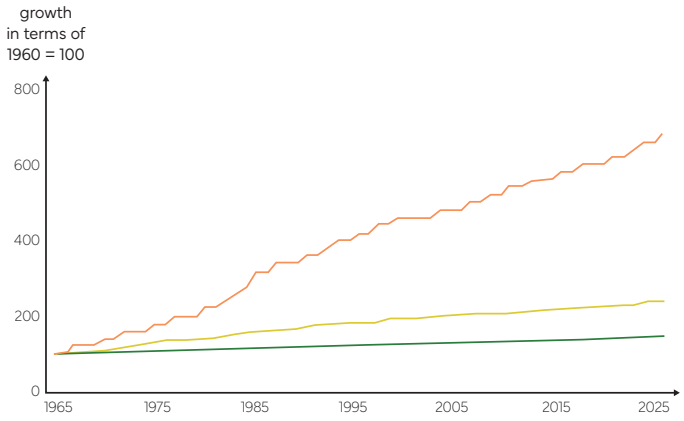
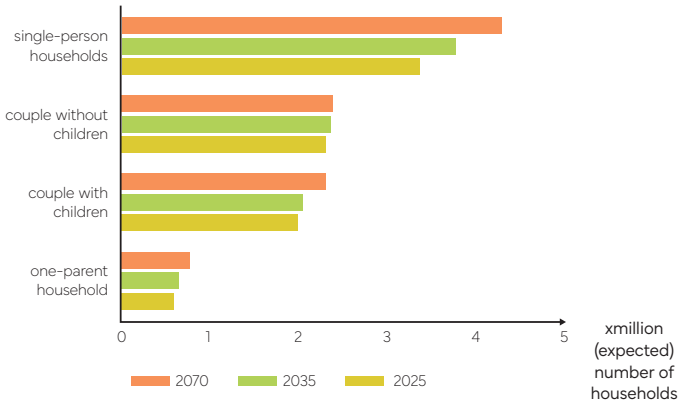


figure 1.3.



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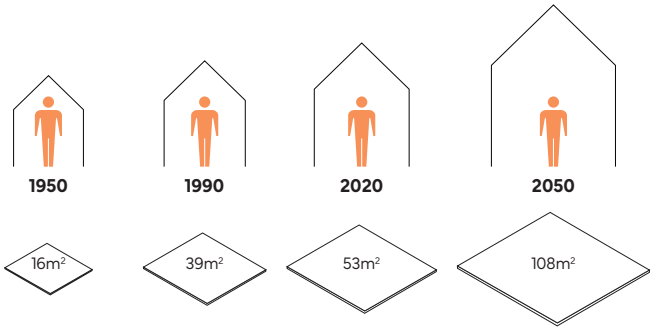


figure 1.5.

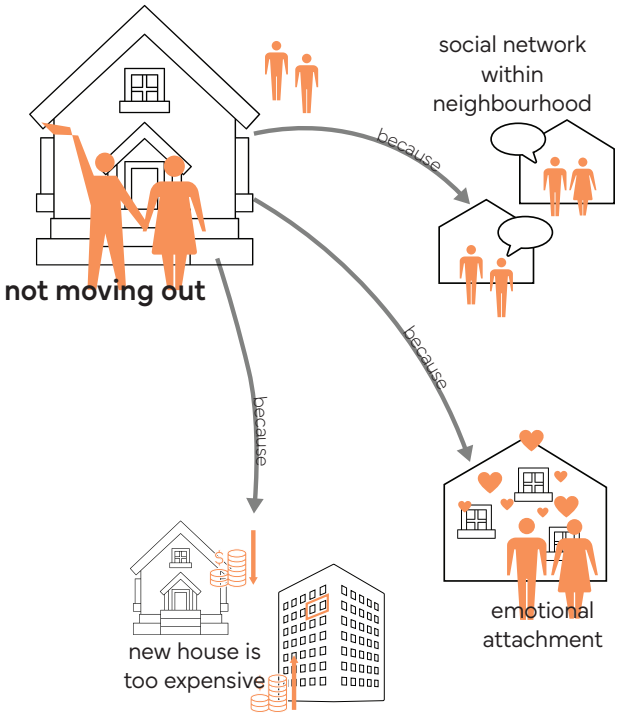
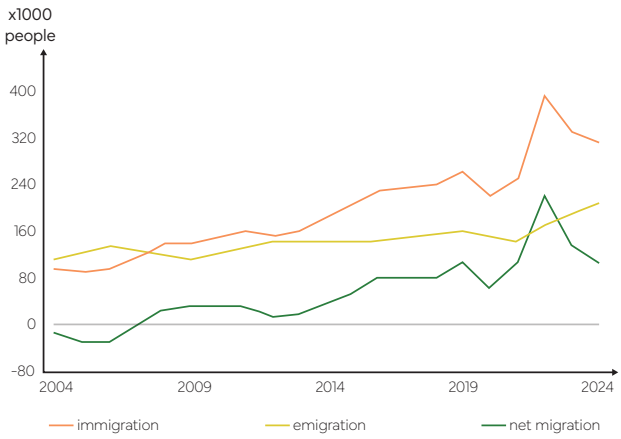


figure 1.6.



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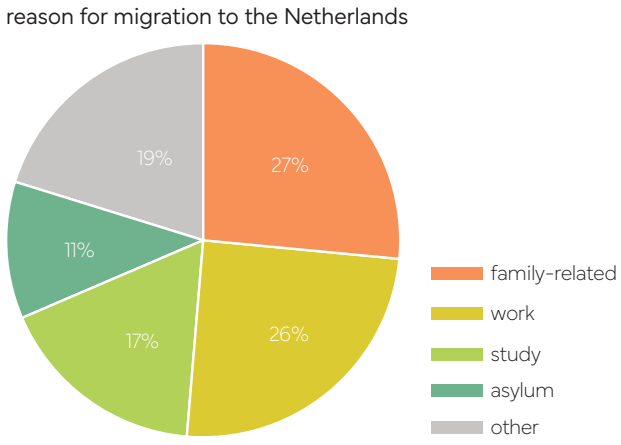

figure 1.8.

relevance.

Analysing the current housing market, we see that many of the newly built houses are getting smaller (Koops, 2024), as opposed to those built 10 years ago (Frans, 2025; Van Den Eerenbeemt & Frijters, 2025). By focusing on the smaller (single-person) households, there are limits in the diversity and flexibility of housing in the future, meaning that when someone wants to move in with their partner or start a family, they will have to look for a (new) bigger house (which might not be available). It also means that if you are migrating to the Netherlands and are accustomed to different (or larger) housing standards, few houses (on the market) will accommodate these needs.

It is expected that our population will keep on getting older (Ministry of Health & Well-being, 2025), that the number of single-person households will continue to increase over the coming years (Klaveren et al., 2021) and that immigration (and therefore the diversification of our population) will not stop anytime soon (Ministerie van Asiel en Migratie, 2025). This means that, to all 'fit' within the Netherlands, a more flexible approach to housing (building) systems is essential if we want to accommodate residents' changing spatial needs.

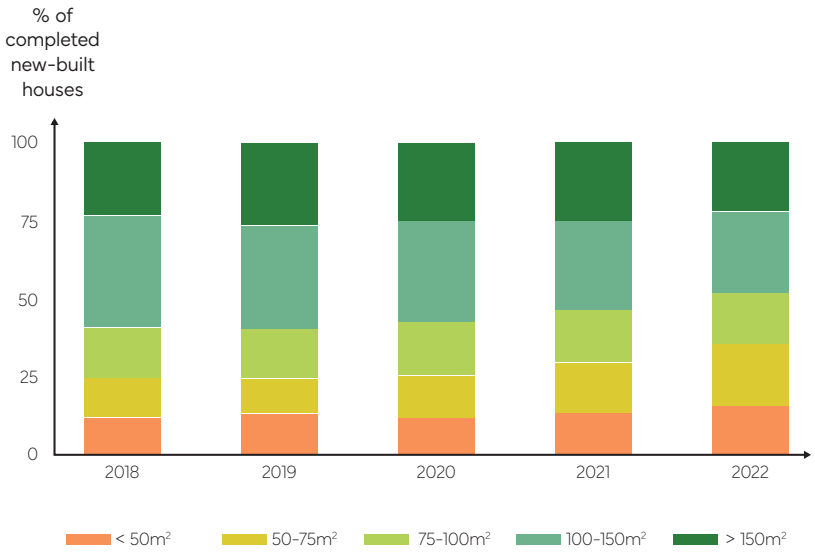

figure 1.9.

figure 1.9. *Size (m^2) of newly-built houses over the past 8 years. Adapted graph from Centraal Bureau Statistiek Nederland or CBS Nederland (March, 2025a)*

figure 1.10. *Ambitions portrayed as visual representations of possible design solutions. Author's own work.*

objective.

This research aims to, through 'research by design', explore how an adaptive housing system can accommodate residents' changing spatial needs and how their perceived needs might be shifted when implementing co-living principles. On the one hand, the research will dive into the technological lens by designing a house that can adapt accordingly. When rooms become 'excessive', they should be able to change in size, position or even households.

On the other hand, by choosing co-living as a tool, the design has an added social value and reduced climate impact (Sandstedt & Westin, 2015; Jeske et al., 2024). The objective is to stimulate a societal shift towards more 'house sharing' (as opposed to single-person households) in the younger generations, 'downsizing' (as opposed to living on too many m^2) in the older generations, and 'multiculturalism' (as opposed to cultural separation). Residents' perceived housing needs will be challenged through household mixing within one residential block, and are further expanded by interaction between neighbours through co-living principles. Some (initial) principles that can be thought of are the inciting of interaction through the circulation spaces in the building, the sharing of outside spaces, laundry spaces, and/or even the kitchen.

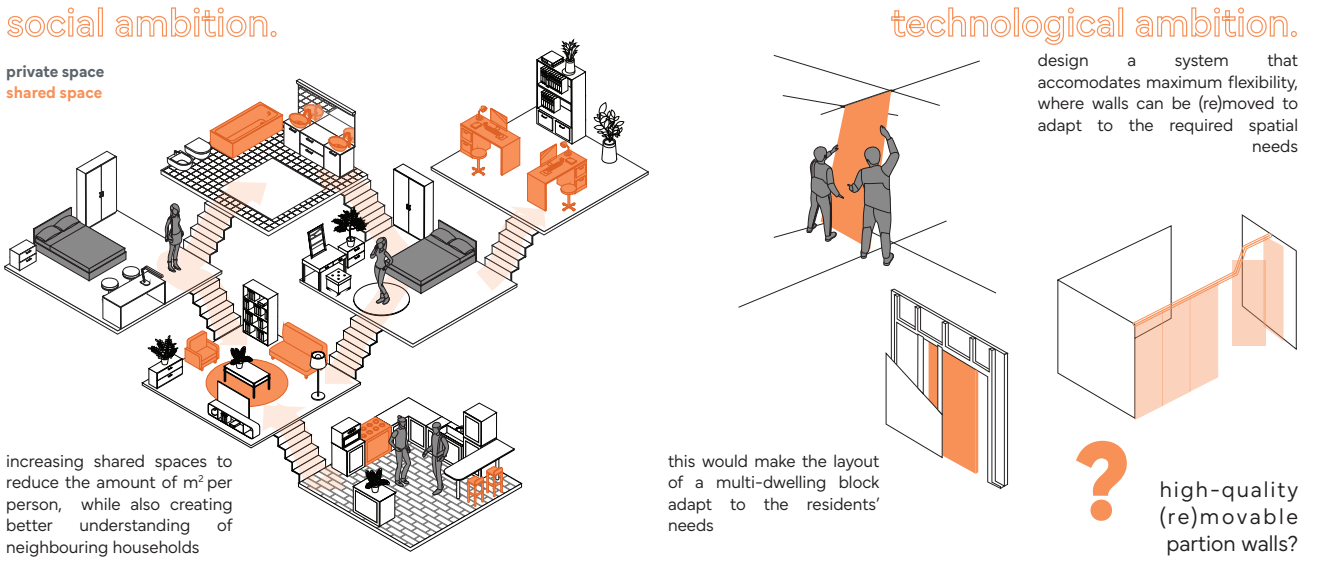

figure 1.10.

research & design (sub-)question(s).

The initial motivation behind this research is the challenge we're facing regarding the (lonely) elderly living in a home that is too big. This report aims to find a way in which a house can stay one's home even when the building is adapted to accommodate more people. This leads to the main 'research & design' question being:

Main 'Research & Design' Question
How can an adaptive housing (building) system be designed to accommodate the changing spatial needs of its residents, while incorporating co-living principles?

Sub-questions

1. What architectural elements define an adaptive housing system? How has this been translated into existing residential blocks?
2. How do residents' spatial needs change over time as well as in relation to their cultural background?
3. How do different households come together within one adaptive housing (building) system?
4. How do existing co-living residential blocks stimulate interaction and understanding among their residents?

figure 1.11. *Positioning of research & design (sub-)questions within the studio brief & approach. Author's work.*

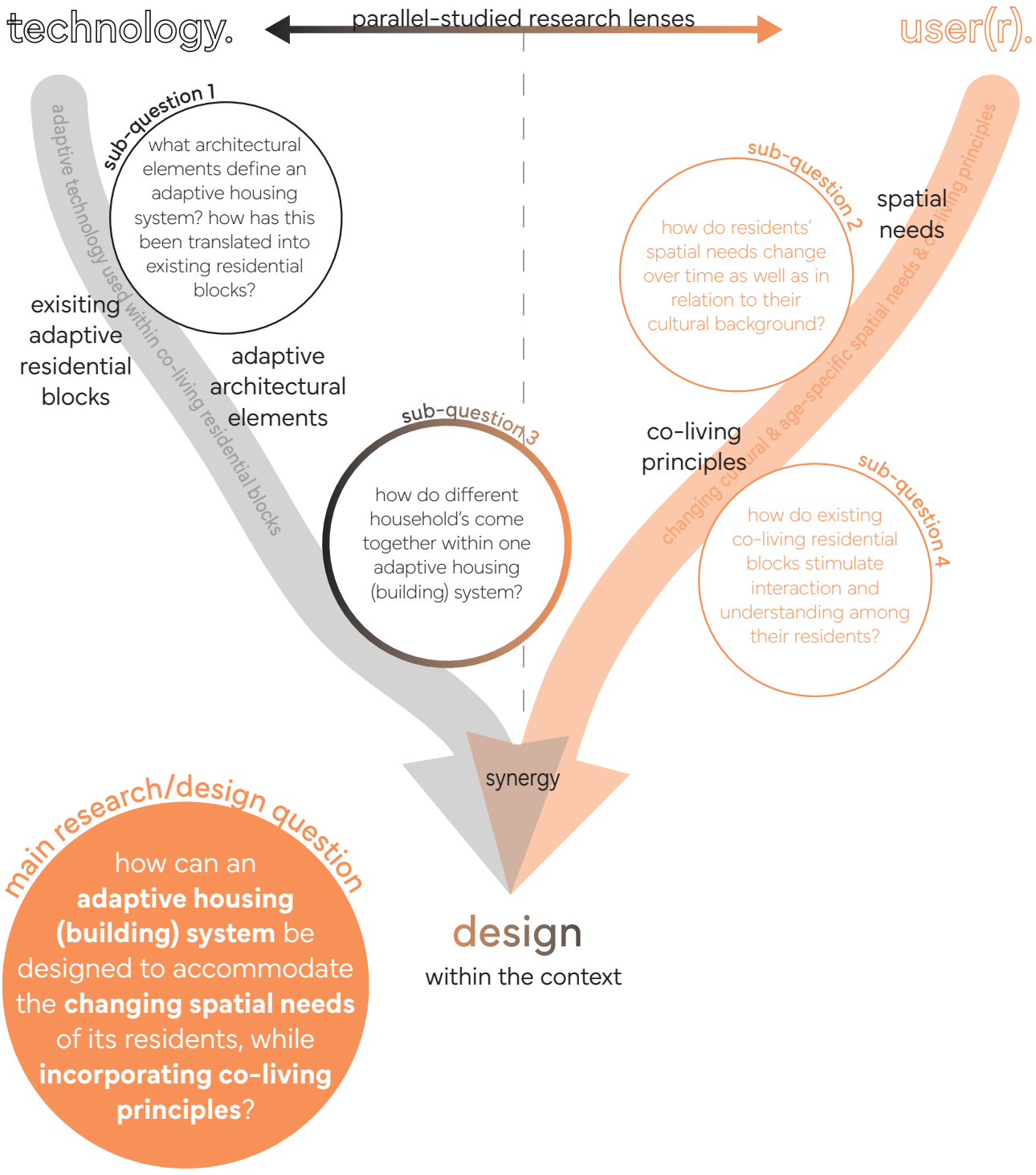
technology.
parallel-studied research lenses
user(r).
sub-question 1
what architectural elements define an adaptive housing system? how has this been translated into existing residential blocks?
adaptive technology used within co-living residential blocks
exisiting adaptive residential blocks
adaptive architectural elements
sub-question 2
how do residents' spatial needs change over time as well as in relation to their cultural background?
spatial needs
changing cultural & age-specific spatial needs & co-living principles
co-living principles
sub-question 3
how do different household's come together within one adaptive housing (building) system?
sub-question 4
how do existing co-living residential blocks stimulate interaction and understanding among their residents?
synergy
main research/design question
how can an **adaptive housing (building) system** be designed to accommodate the **changing spatial needs** of its residents, while **incorporating co-living principles**?
design
within the context

figure 1.11.



figure 1.12.



figure 1.13.

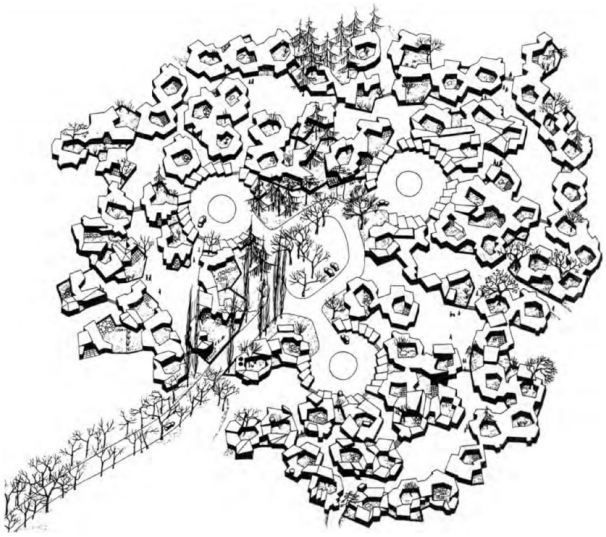

figure 1.14.

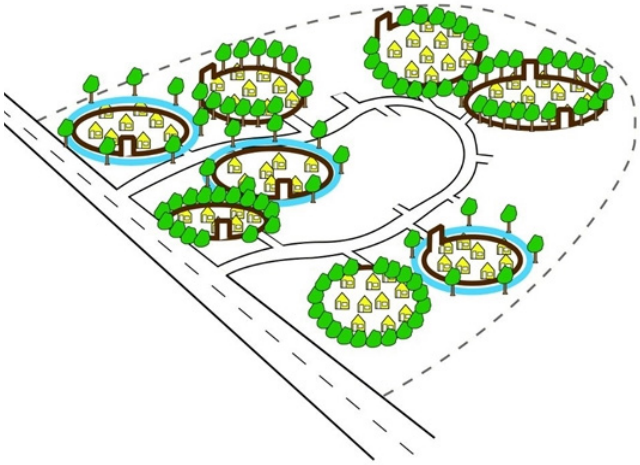

figure 1.15.

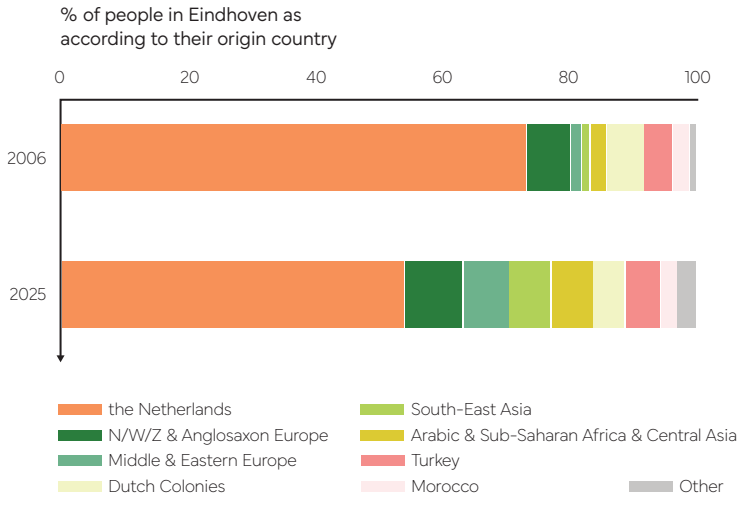

figure 1.16.

scope.

The design of an "adaptive housing (building) system that incorporates co-living principles" can be seen as a somewhat experimental housing typology. Therefore, diving deeper into the historical context of 'experimental housing' in the Netherlands (& Eindhoven) allows us to select a suitable design site.

During the 70s & 80s, the Netherlands developed several 'new' & 'experimental' housing typologies. One of these is the 'bloemkoolwijk' (Bron et al., 2021). The 'bloemkoolwijk' is considered a housing typology that mimics a 'woonerf' (living street), providing communal outside spaces that stimulate interactions between neighbours (Blom, 2023). The goal of this design was to bring the human scale back, which meant these neighbourhoods became very low-rise (see figures 1.12.-1.15.) and were flooded with small-scale urban furniture like (open & closed) courtyards, smaller plants and narrow & tortuous streets. In other words, the architectural design was focused on how these elements would be applied in the outside space, which made the houses themselves very standardised and rigid (Ministerie van Onderwijs, Cultuur en Wetenschap, 2024). Utilising the 'bloemkoolwijk' as a departing point for this research allows for a reinterpretation of this 'experimental' housing typology (a typology that is already focused on more neighbour interaction).

Theoretically, this design research could lead to any 'bloemkoolwijk' in the Netherlands, but to embed the design within a context, a neighbourhood in Eindhoven will be selected as a case study. This is due to the city's expected economic growth and the need for at least 40,000 new houses (OpenEindhoven, 2025). Additionally, the presence of major companies, like ASML (Brainport Eindhoven et al., 2020), which have ties with international investors, makes the cultural diversification of Eindhoven inevitable (Basisregistratie personen, 2025). These two reasons show a clear relation to the problem statement, but how can they also relate to the design question?

figure 1.12. *Drawn impression of a bloemkoolwijk. From the 'bloemkoolwijk' Layout-4 arcticle by Stimuleringsfonds voor Architectuur & Bureau Middelkoop (2008)*
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figure 1.17. *Iconography for houses needed in EIndhoven. Author's work.*
figure 1.18. *Map of the Netherlands & Eindhoven. Author's work.*
figure 1.19. *Birds-eye isometric map of Limbeek and surroundings, with possible design sites. Author's work.*



figure 1.17.

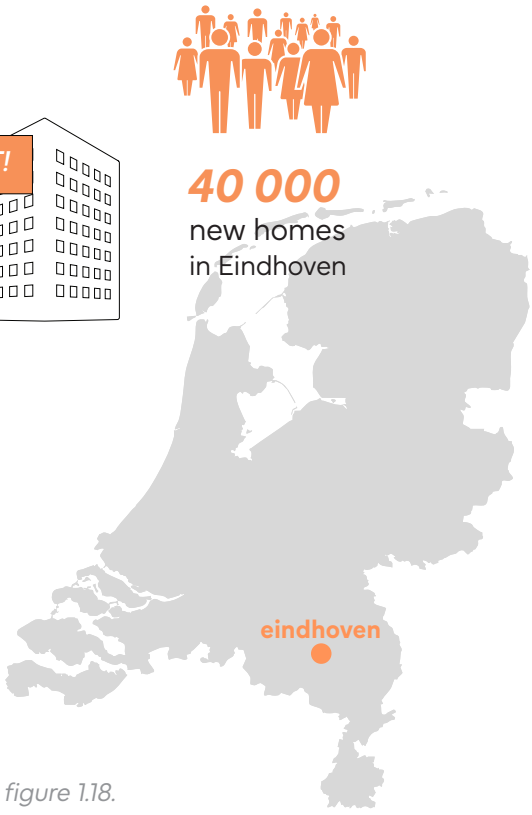
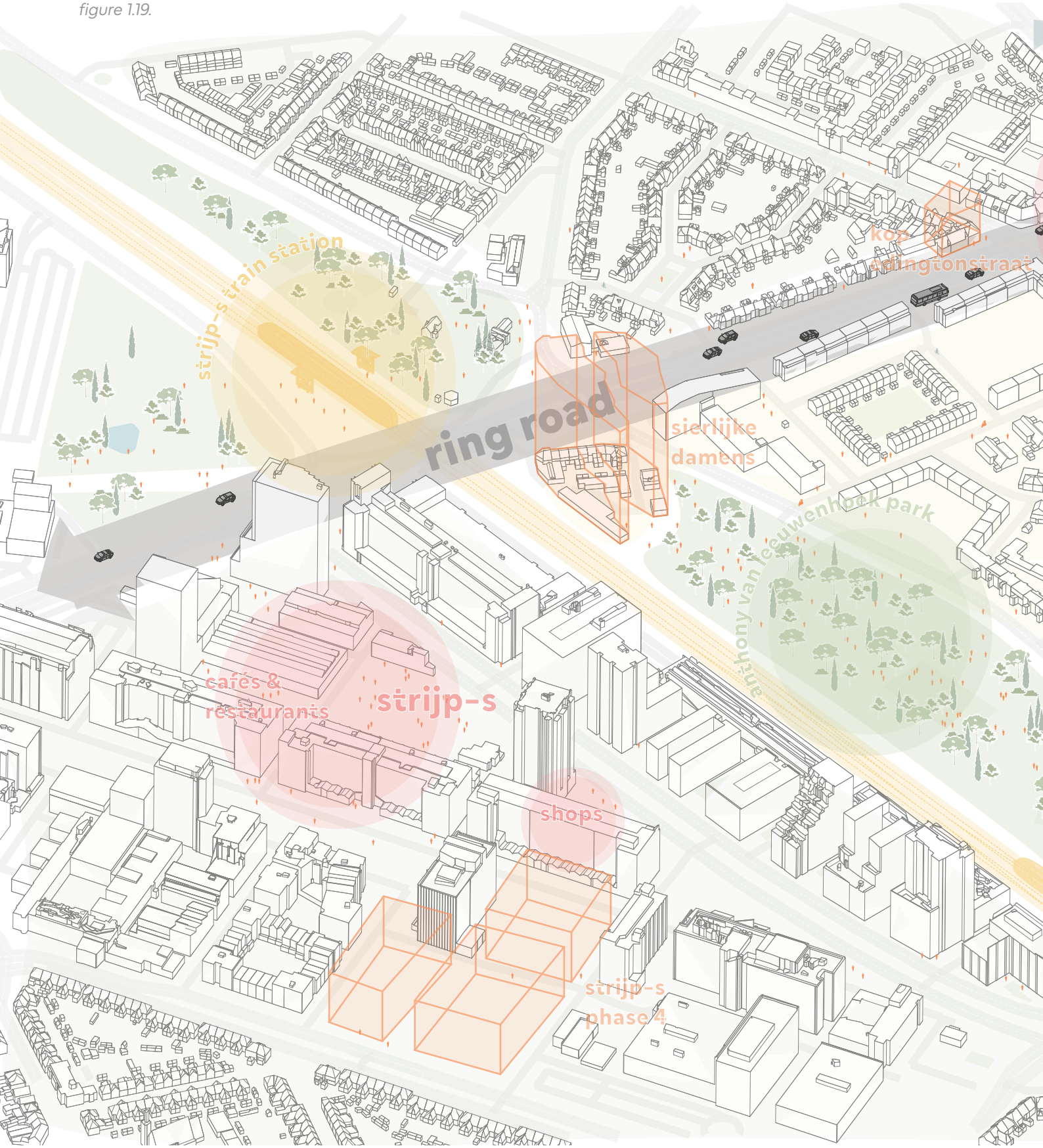
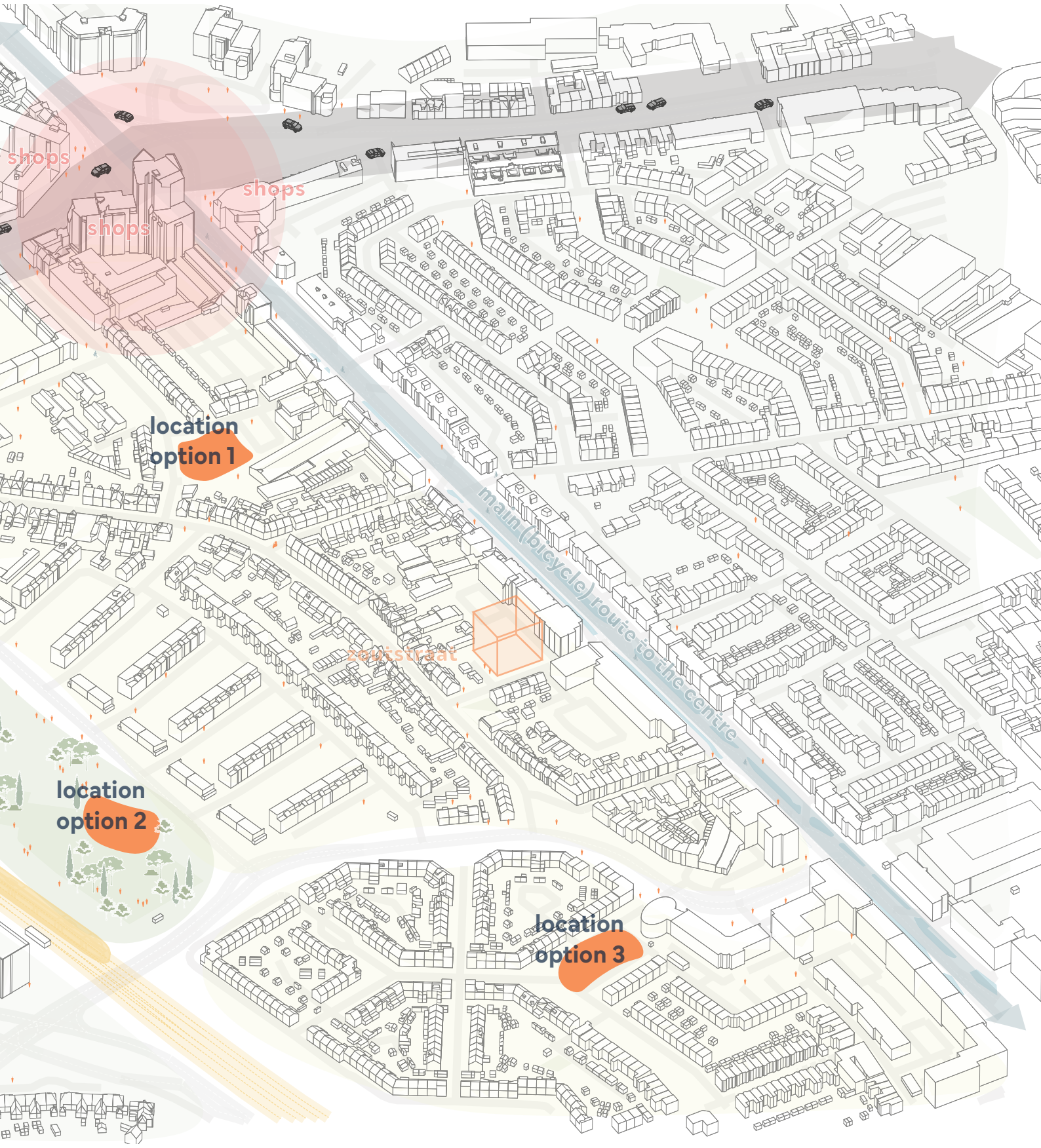


figure 1.18.

figure 1.19.


strijp-s train station
ring road
kop
edingtonstraat
sierlijke
damens
van leeuwenhoek park
anthony
cafés &
restaurants
strijp-s
shops
strijp-s
phase 4


shops
shops
shops
location
option 1
main (bicycle) route to the centre
zeilstraat
location
option 2
location
option 3

scope (cont.).

Limbeek Zuid is one of the 'bloemkoolwijken' in Eindhoven. This neighbourhood is situated between many of the current developments (Strijp S, Knooppunt XL & Vondelkwartier), which makes its outdated character even more relevant. Additionally, the neighbourhood has been noted as being one of the 'critical points of intervention' in the city of Eindhoven, due to people not finding (affordable) appropriate housing (within the neighbourhood), feeling unsafe and a general disconnection among neighbours (Gemeente Eindhoven, 2023). This has already led to future zoning plans (for Limbeek Zuid) to use more 'bottom-up' approaches that build a community that trusts each other (Duivenvoorden & Sterrenberg, 2025).

In sum, this makes Limbeek Zuid a perfect 'test site' for the experimental design expected to be developed from this research.

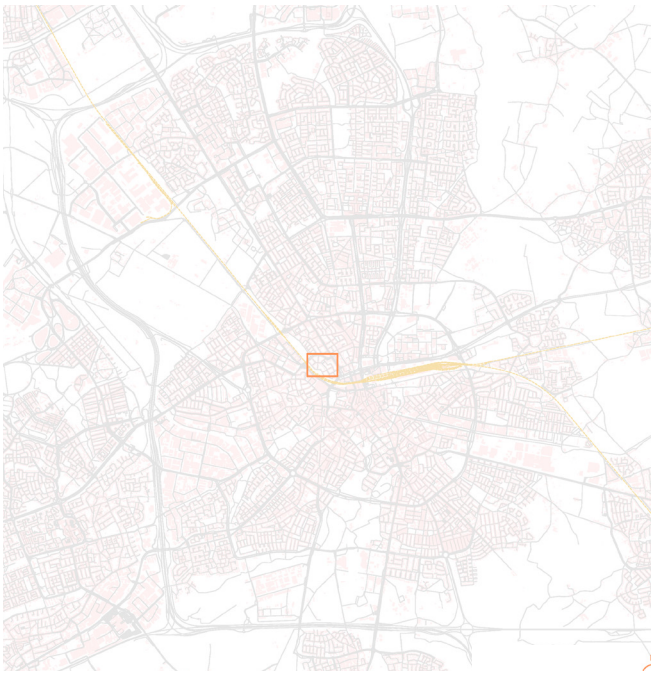


figure 1.20. *Limbeek, as situated within the context of Einhoven.*
figure 1.21. *Social analysis pie charts of Limbeek. Author's work adapted from AlleCijfers (2025).*

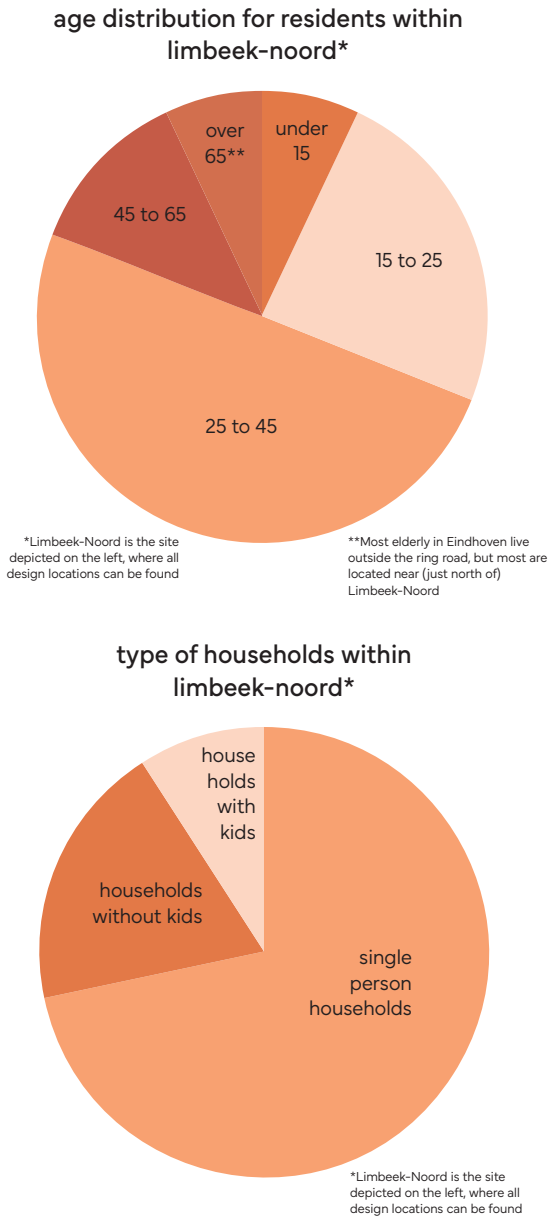

age distribution for residents within limbeek-noord*
over 65**
under 15
45 to 65
15 to 25
25 to 45
*Limbeek-Noord is the site depicted on the left, where all design locations can be found
**Most elderly in Eindhoven live outside the ring road, but most are located near (just north of) Limbeek-Noord
type of households within limbeek-noord*
house holds with kids
households without kids
single person households
*Limbeek-Noord is the site depicted on the left, where all design locations can be found

figure 1.21.



approach.

The overarching approach is to ‘research by design’. Therefore, when designing this new architectural system, first, gather initial information, then start design explorations through prototyping, and then iterate on these (while gathering additional information). This last step is especially important to make clearly argued design choices. These design choices & iterations will go on to support an integrated proposed design solution.

methodology.

As can be deduced from the research question, the main aim of this research is to design an adaptive housing system that accommodates residents' changing spatial needs while incorporating co-living principles to stimulate a behavioural shift in residents' perceived housing needs. In Figure 1.11., we get to understand the two lenses through which the design is developed: the technology and the user (or function).

These two lenses will first be analysed in terms of 'the existing'. Starting with the technological lens, literature will be selected and reviewed regarding the development of adaptive housing throughout history. Adaptive theories from Le Corbusier (1914), to Harbraken (1961), to Brand (1994) will be reexamined to understand their value and to identify architectural elements that are associated with them. After that, through case studies, existing buildings that implement these theories will be analysed to understand how they are applied in practice. Because many building typologies use these theories, the selected cases will be narrowed down to residential blocks where residents can adapt or expand their houses easily, or where shared spaces are implemented within the block. Finally, these analyses and evaluations will lead to key design principles (answering sub-question 1).

The use(r) lens will apply a similar approach. Residents' spatial needs will be assembled through household data analyses (like that of the BPD, 2022) as well as cultural housing literature. This data will then be synergised to create 10 personas that mimic the different households (in terms of size, age and culture) present within the scope of this research. This investigative research, along with the personas, will again lead to key design principles (answering sub-question 2). Alongside this investigative research, literature will be collected to evaluate existing co-living principles. After that, just like with the technological lens, case studies will be analysed to identify possible housing typologies that favour co-living to identify architectural elements that stimulate interaction (answering sub-question 4).

Lastly, when synergising these lenses, design explorations in the form of floor plans, sections and massing studies will be performed. Firstly, design principles from sub-question 1 & 2 will be synergised to answer sub-question 3, which will ground the argumentation for future design choices made on the building scale (see Appendix D). Testing co-living housing typologies within the existing context will provide argumentation for the chosen volumes and the way it performs within the urban fabric. These tests, along with co-living literature evaluations, will provide argumentation for the type of circulation and shared spaces within the building.

figure 2.1. *Image of inspirational model, that stimulated further developments within the project. Author's work.*
figure 2.2. *Image of demounted inspirational model, that stimulated further developments within the project. Author's work.*



figure 2.1.



figure 2.2.

theoretical framework.

As previously described, the research can be split into the technical and use(r) lens. Therefore, the theoretical framework can also be viewed through these two lenses.

adaptive housing (building) systems.

In his research, Estaji (2017) describes the ever-changing needs of the users in a building as the biggest issue when it comes to designing a building. Therefore, a building must be adaptive, "capable of different social uses, and flexible, capable of different physical arrangements" (Groak, 2002). Le Corbusier (in 1914) first described adaptability as a 'domino system' where the interior is separated from the exterior. This separation was later translated into layers by Habraken in 1961, when defining the open building. These layers were later defined in terms of time by Duffy (in 1990) and Brand (1994). They describe them as 'shearing layers' that all have their own degradation time and therefore require renewal at different moments throughout the building's lifetime. Adding the dimension of time allows us to relate the building to both its physical elements and its use over time. In Schmidt III et al.'s (2010) research, they go so far as to state that users' needs are the main driver for a building to function adaptively and that if the architecture doesn't invite one to adapt it, then people won't adapt it (as confirmed by Hertzberger in 1991).

If we were to then compare these layers to, for example, someone's lifetime (in years as well as household sizes), it is clear that some layers may require renewing within a single person's lifetime as opposed to others (see Figure 2.1.). This simple comparison allows us to very easily interpret that the site, the structure and the façade are all architectural features that 'last' more than a person's lifetime, while the 'infill' (the services, the space plan and the 'stuff') will require renewing within a person's lifetime (even if there's no use(r) change). Therefore, designing an adaptive building starts with a structure and façade that allows for different spatial needs without them needing to be changed, and ends with a 'smart' service and space layout that can easily accommodate different needs. Therefore, defining a grid size and clever service shaft placement that allows for different layouts is essential.

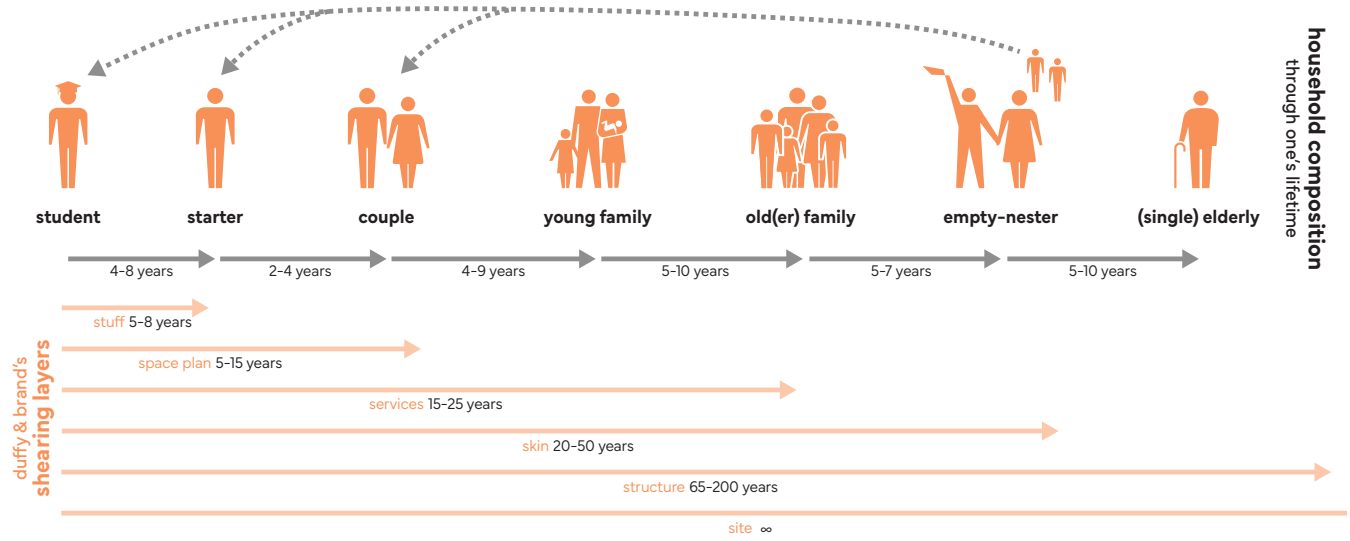


figure 2.3.

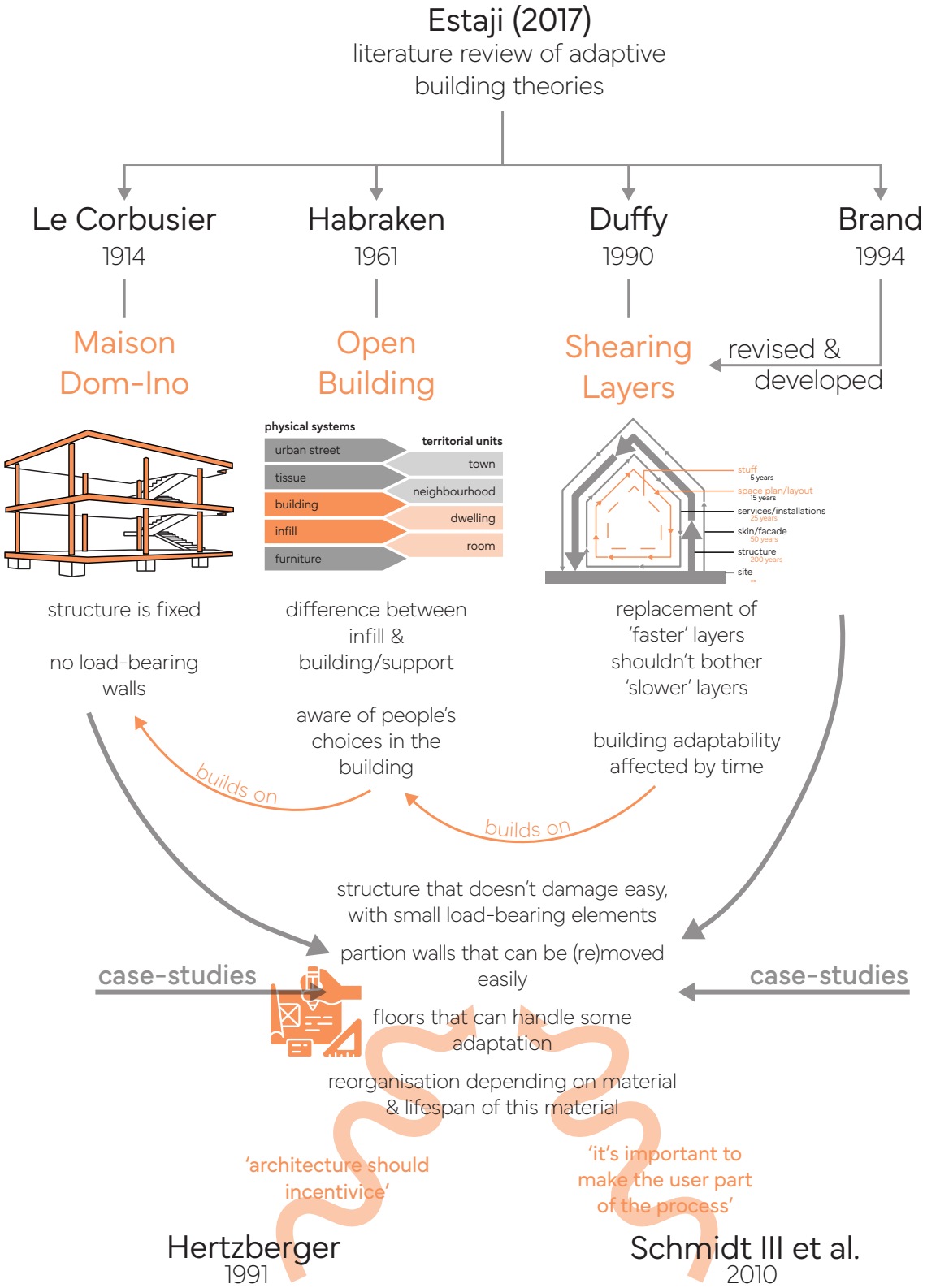

Estaji (2017)
literature review of adaptive building theories
Le Corbusier
1914
Habraken
1961
Duffy
1990
Brand
1994
Maison Dom-Ino
Open Building
Shearing Layers
revised & developed
physical systems
territorial units
urban street
town
tissue
neighbourhood
building
dwelling
infill
room
furniture
stuff
5 years
space plan/layout
15 years
services/installations
25 years
skin/facade
50 years
structure
200 years
site
structure is fixed
no load-bearing walls
difference between infill & building/support
aware of people's choices in the building
replacement of 'faster' layers shouldn't bother 'slower' layers
building adaptability affected by time
builds on
builds on
structure that doesn't damage easy, with small load-bearing elements
partion walls that can be (re)moved easily
floors that can handle some adaptation
reorganisation depending on material & lifespan of this material
case-studies
case-studies
'architecture should incentivice'
'it's important to make the user part of the process'
Hertzberger
1991
Schmidt III et al.
2010

figure 2.4.

% of people in limbeek as according to their origin country.

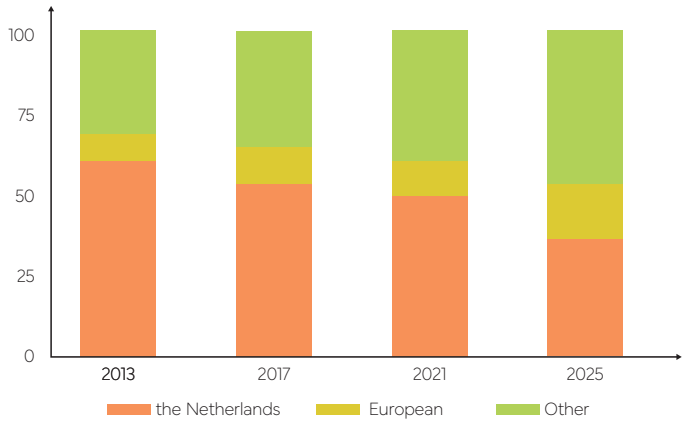
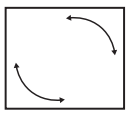


figure 2.5.

rules based on age-related spatial needs.

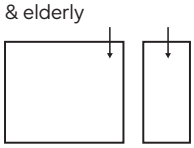
Rule 1 – the toilet & bathroom

(young) single person



in same space

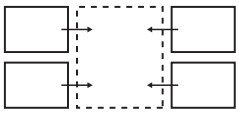
couples, shared housing, families & elderly



seperate

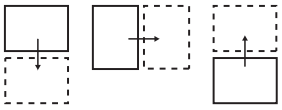
Rule 2 – outside space

young singles & couples



shared

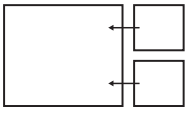
families & older couples/singles



private

Rule 3 – presence of a home office

young couples & small families



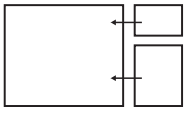
office (or baby room) seperate from bedroom

young singles & bigger families



office in the bedroom

elderly



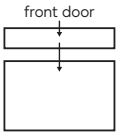
no office, but guest bedroom

figure 2.6.

rules based on cultural spatial needs.

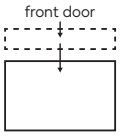
Rule 1 – the front door/entrace space

moroccan



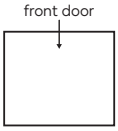
indoor buffer

chinese



transition in- to outside

all other cultures



no need for buffer

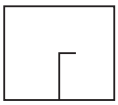
Rule 2 – the kitchen

dutch, german & polish



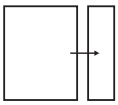
open

indian & moroccan



semi-open

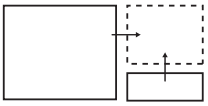
turkish, chinese & indonesian



seperate

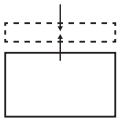
Rule 3 – outside space

indian, turkish, indonesian, dutch, german & polish



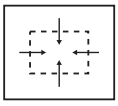
connected to kitchen and/or living (& dining) room

chinese



as a transition space

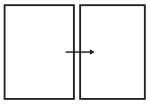
moroccan



enclosed by house

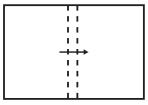
Rule 4 – bedroom

turkish, indonesian & chinese



seperate (privacy is important)

moroccan, indian, dutch, german & polish



preferably seperate, but studio is accepted when living alone

figure 2.7.

theoretical framework (cont.).

changing spatial needs.

Residents' reasons for changing spatial needs can be separated into two: a change in household size or a cultural difference. Therefore, when defining the theoretical framework and assembling this information, it is important to consider both these factors. Due to the nature of this research, the household size-related spatial needs have mainly been defined by the personas described in the Dutch 'Bouwfonds Gebiedsontwikkeling Whize'. Within this database, clear households are defined by age, the presence or absence of children and their economic situation. The main spatial elements associated with the personas, which have (initially) been defined by this database are: the number of floors within the house, the type of outside space (& the presence of green nearby), the separation of the toilet from the bathroom and the presence of an 'extra room' as either a home office or a guest room.

To narrow down the scope of this research, focus has been put on the origin countries that are represented with over 1,5% within the population of Eindhoven. These are: the Netherlands, Turkey, India, Morocco, Indonesia, Poland, Germany & China (see Appendix A). To define culture-related spatial needs, different types of literature have been explored since there are few databases that gather this information. By interpreting traditional housing layouts (like those analysed by Waterson, 1990; Taylor, 2012; Bertram, 2013; Legacy, 2024; Chahbi, 2024; Team Kaarwan, 2025) along with more recent examples within these countries (like those described by Y. Wang, 2005; ▪▪▪, 2012; Taylor, 2012; Van Gameren, 2015; Competitive Enterprise Institute, 2018; Rowe & Fu, 2022; L. Wang et al., 2024; Rosling Rönnlund, 2025; Saaid, 2025), recurring spatial qualities can be identified within. These qualities can be classified in both the categories defined earlier, along with additional spatial categories like: the entrance space, the type of kitchen and its placement, the willingness to share the outside space and the importance of privacy when it comes to the bedroom

figure 2.3. *Shearing layers defined in terms of a person's life (and the households they go through). Author's work.*
figure 2.4. *Overview of existing 'adaptive building' research & its influence. Author's work.*
figure 2.5. *Cultural diversification of the population in the area of Limbeek. Author's work based on AlleCijfers (2026).*
figure 2.6. & 2.7. *Rules developed, by author, based on the theoretical reserach rageding user's needs. Author's work.*
figure 2.8. *List of countries where the population of Eindhoven originates from. From AlleCijfers (2026).*

Country of origin	Total People	Percentage
Netherlands	134959	54.20%
Turkey	13581	5.45%
India	9214	3.70%
Morocco	6975	2.80%
Indonesia	5631	2.26%
Poland	4956	1.99%
Germany	4682	1.88%
China	4167	1.67%
Suriname	3731	1.50%
Syria	3293	1.32%
Belgium	2760	1.11%
Curacao	2416	0.97%
Spain	2309	0.93%
Rumania	2098	0.84%
Bulgaria	2061	0.83%
Ukraine	2004	0.80%
Italy	1935	0.78%
Iran	1882	0.76%
Brazil	1746	0.70%
UK	1714	0.69%
Portugal	1605	0.64%
Somalia	1469	0.59%
Greece	1359	0.55%
Russia	1241	0.50%
Afghanistan	1231	0.49%
France	1225	0.49%
USA	1196	0.48%
Irak	1160	0.47%
South Africa	1110	0.45%
Egypt	1070	0.43%
Hungary	909	0.37%
Vietnam	770	0.31%
Bosnia Herzegovina	686	0.28%
Aruba	618	0.25%
Ethiopia	616	0.25%
Thailand	590	0.24%
Philippines	573	0.23%
Serbia	528	0.21%
Eritrea	512	0.21%
Colombia	499	0.20%
Pakistan	489	0.20%
Nigeria	479	0.19%
Australia	388	0.16%
Ghana	370	0.15%
Canada	367	0.15%
Cape Verde	26	0.01%
Unknown	15787	6.34%
	248987	

figure 2.8.

theoretical framework (cont.).

co-living principles.

Co-living originated in Scandinavia (in the early 1930s), but became popular around the 60s & 70s in other countries (Czischke et al., 2023). Throughout history, different forms of co-living have developed, like 'Centraal Wonen' (in the Netherlands), 'Kollektivhus' (in Sweden) or 'Samenhuizen' (in Belgium) (De Vos and Spoormans, 2022; Czischke et al., 2023). This has led to different forms of sharing and different degrees of privacy. Both Manting et al. (2022) & Czischke et al. (2023) state that giving people the freedom to choose the degree of privacy that they need is essential for co-living to succeed. Sharing spaces shouldn't be an obligation but a choice. Therefore, the more 'successful' co-living residential blocks tend to be designed through a bottom-up approach, where people can shape the shared spaces and understand their value from the very beginning.

In Vestbro's (2010) report, clear design guidelines are provided for 'successful' co-living designs based on studies of existing buildings and architects' input on this topic. He states that one of the most important ways to stimulate interaction and the use of shared spaces is through circulation. Circulation routes should almost 'force' people to walk past each other('s houses). Shared spaces, like outside balconies, terraces, laundrettes, shared living rooms or even container spaces and storage units, should be on key nodes within the circulation plan.

Additionally, in Gehl's Cities for People (2010), he describes some scale-related design guidelines that improve the interaction and collectivity within and around a residential block. Like locks within the same residential unit not being more than 12.5m apart or buildings not being higher than 5 floors, since both these distances are the maximum distance from which a person can still recognise someone.

Initial comparisons between these co-living design guidelines and the selected case studies indicate that most buildings do indeed follow these guidelines, which provides a grounded framework for further design explorations (see Appendix C, for further information).

figure 2.9. *Overview of existing co-living literature. Author's work.*
figure 2.10. *Gehl's principles defined within the human scaled urban context. From Gehl (2010).*

trends in co-housing

Uyttebrouck et al.
2020

van Vliet
2025

Clark et al.
2018

Uyttebrouck and Teller
2023

reasons for sharing

Czischke et al.
2023

Jeske et al.
2024

De Vos and Spoormans
2022

Sandstedt & Westin
2015

Uyttebrouck et al.
2020

developments in sharing

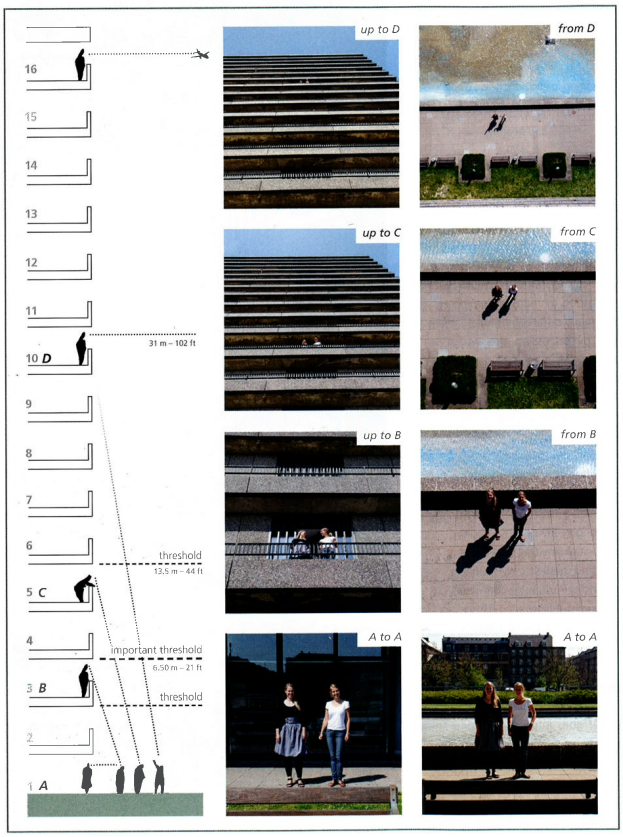
Manting et al.
2022

Gehl
2010

Vestbro
2010

spatial requirements for sharing

figure 2.9.



94 PEOPLE CITIES

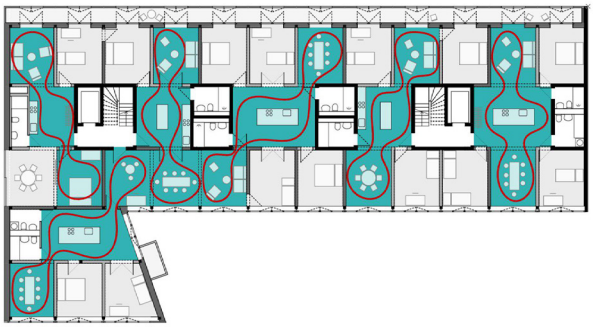
figure 2.10.

results.

Several spatial qualities, for the technical and use(r) lens, have been defined by the theoretical framework. Throughout this chapter, these qualities, along with the pre-defined personas and the case study analyses, will be translated into architectural design principles that provide input for the design explorations. These principles are on building scale (like the (structural) grid size, the service shaft placement, the circulation routes or the household space plans) and the urban scale (like the shape or height of building volumes or the embeddedness of the design).

case study analyses and testing.

Case study analyses have been done for buildings that relate to the 'open building' theories (the technical lens) and for housing typologies that implement 'co-living' principles (the use(r) lens). These can all be found in Appendices B & C, respectively. Due to the vast amount of 'open building' design concepts, the selected cases have been narrowed down to residential blocks that apply both the 'open building' concept and either stimulate people (from a bottom-up approach) to adapt their home (Quinta Monroy, Modulus Matrix, Laan van de Vrede) or provide shared spaces within the building (Adaptive Co-Housing, San Riemo, La Borda).



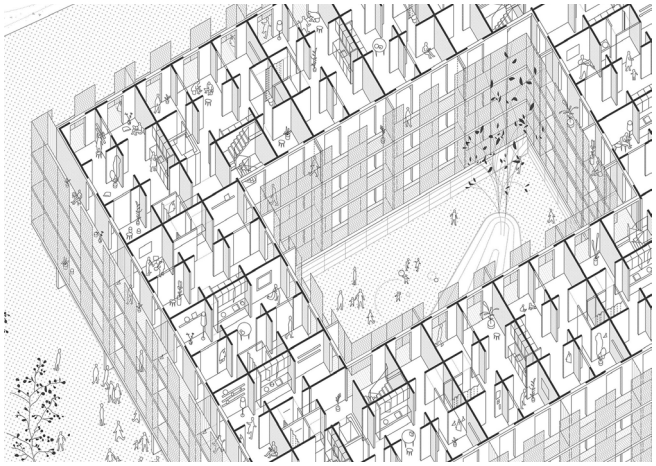






figure 3.1., 3.2., 3.3.

figure 3.1., 3.2., 3.3.
Floorplan & pictures of San Riemo, designed by SummaCumFemmer (Munich, 2020). From 027. SummaCumFemmer (2024).





figure 3.4, 3.5, 3.6.

figure 3.4., 3.5., 3.6.
Axonometry & pictures of Modulus Matrix, designed by Peris+Toral (Barcelona, 2020). From Peris+Toral (n.d.).

As for the co-living housing typologies, cases have been chosen based on their (historical & physical) context. Puu-Käpylä (1925, Helsinki) & meer&deel (2024, Eindhoven), both representing the guest house typology; La Borda (2018, Barcelona) & Modulus Matrix (2020, Barcelona), representing the gallery typology; and the 'bloemkoolwijken' (1970-80s, the Netherlands, see also Bron et al., 2021) representing the 'woonerf' typology.



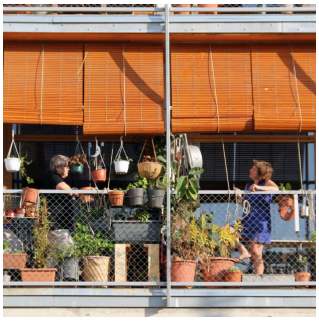




figure 3.7., 3.8., 3.9.

figure 3.7., 3.8. 3.9.
Site plan & pictures of Puu-Käpylä, designed by Marrti Välikangas & Akseli Toivonen (Helsinki, 1925). From Mooij (2010), Paavilainen, Heikkinen, & Niskanen, (2024) & author's work.





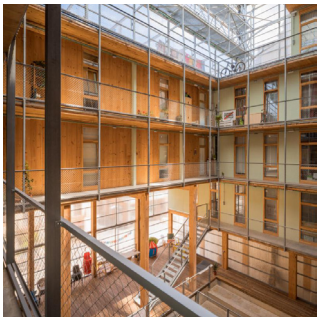


figure 3.10., 3.11., 3.12.

figure 3.10., 3.11., 3.12.
Floorplan & pictures of La Borda, desgined by Lacol (Barcelona, 2020). From Miralles, L. (2020)

case study analyses and testing (cont.).

'open building' analyses & testing.

From the 'open building' analyses, there are three main takeaways that recur throughout the different cases: modules should be stacked with a maximum of 3 behind each other (from façade to façade), the 'wet cells' (kitchens and bathrooms) should be in the middle module & the service shafts should always be placed on alternating grid lines and always one grid line removed from the façade (see Figure 3.13. for clarification). Additionally, the cases also provided six different grid sizes, which were all tested by projecting the rooms present in a home into them (a master or regular bedroom, a home office, a living room, a dining room & a wet cell, the kitchen & bathroom). These tests can be found in Appendix B.

What becomes evident is that the smaller grid sizes (3x3.8, 3x2.2, 3x3m) make it hard to 'fit' certain functions within one grid size, like a double bed bedroom (with a wardrobe), a comfortably spacious living or dining room or even a wet cell with a closed kitchen and a bathroom. The size 3.6x3.6m (which is also that of most office buildings) generally fits all spaces, but gives the design little direction, which is something rectangular grids like 3.6x3.8 & 3.8x4.1m do. These larger grids are generally slightly too big for many of the spaces, but due to their verticality, allow spaces to be better connected amongst each other because of the 'buffer' created with the rectangular shape as opposed to the square shape. Therefore, choosing a grid that is 3.6x3.6m or bigger is the conclusive design principle.

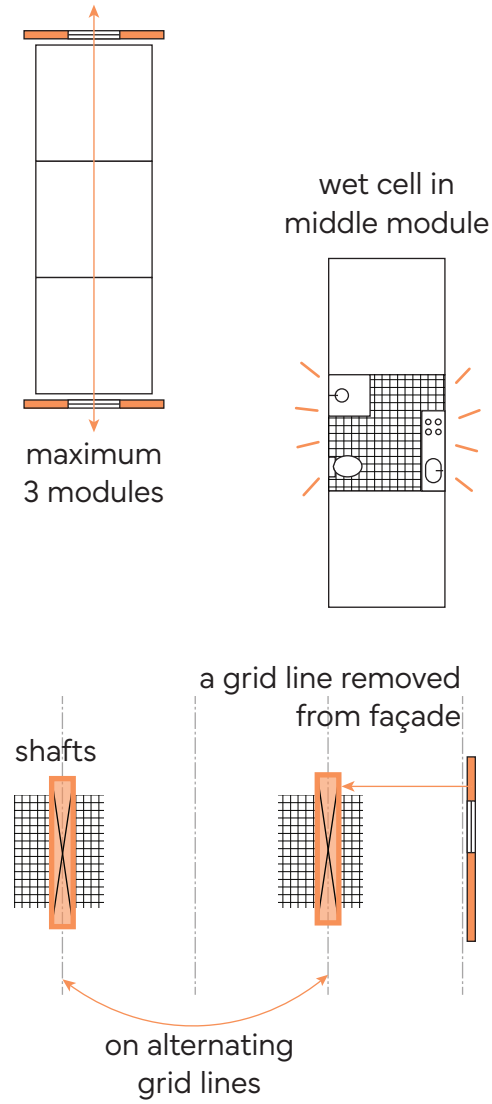
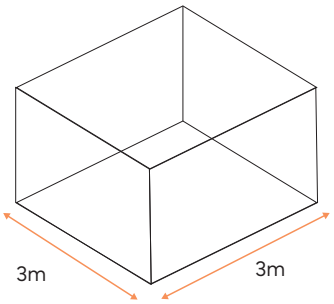


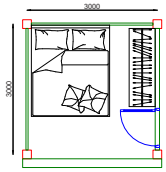
figure 3.13.

figure 3.13. *Explanatory diagrams regarding main conclusions from the 'open building' analyses. Author's work.*

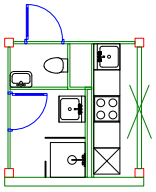
figure 3.14., 3.15., 3.16., 3.17. *A selection of the grid size studies, based on the selected case studies. Further research can be found in Appendix B. Author's work.*



grid size is 3x3 m



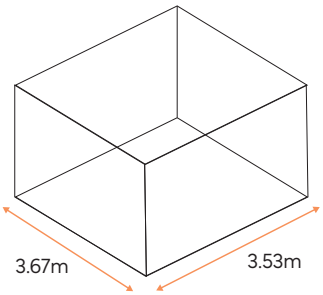
bedroom with double bed



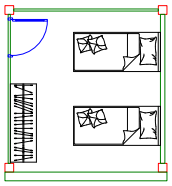
wet cell (bathroom & kitchen)

figure 3.14.

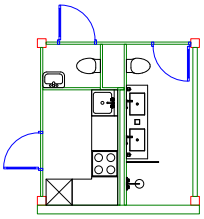
figure 3.15.



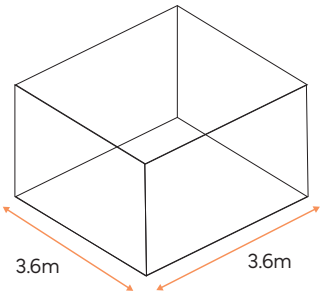
grid size is 3.67x3.53 m



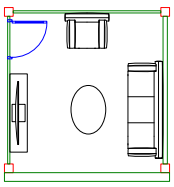
bedroom with (two) single bed(s)



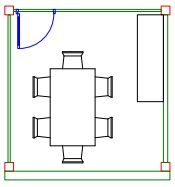
wet cell (bathroom & kitchen)



grid size is 3.6x3.6 m

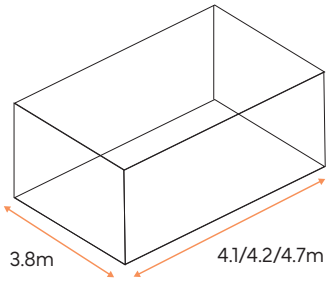


living room

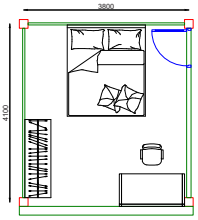


dining room

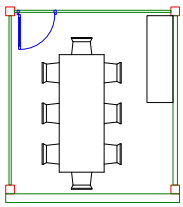
figure 3.16.



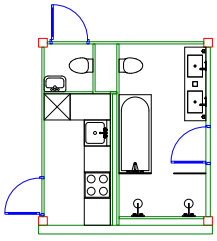
grid size is 3.8x4.1 m



bedroom with double bed



dining room



wet cell (bathroom & kitchen)

figure 3.17.

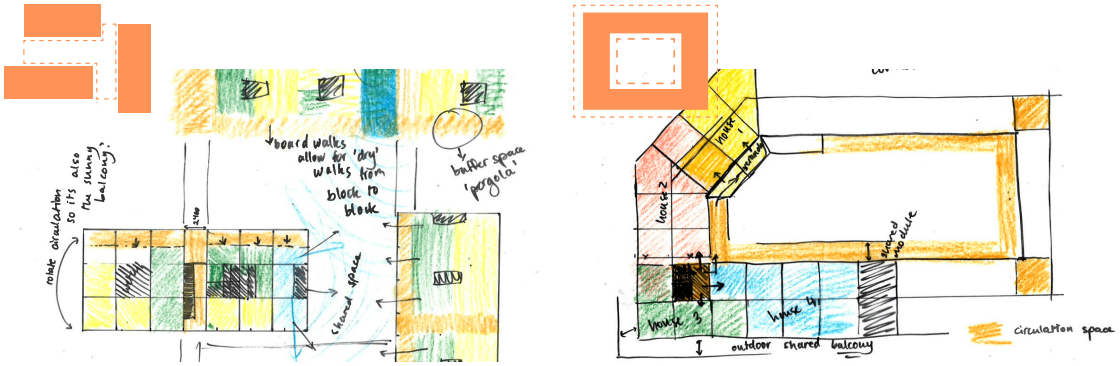


figure 3.18.

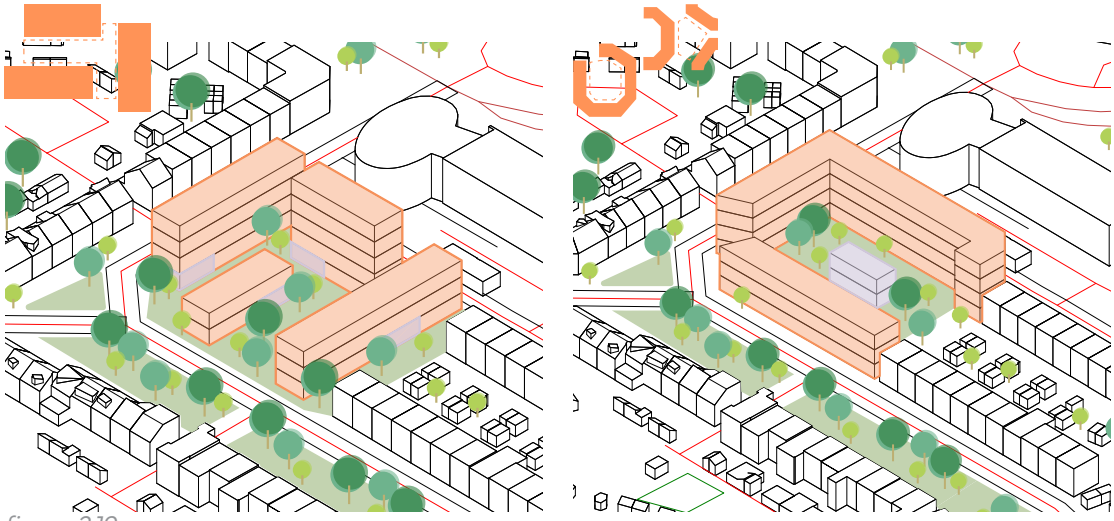


figure 3.19.

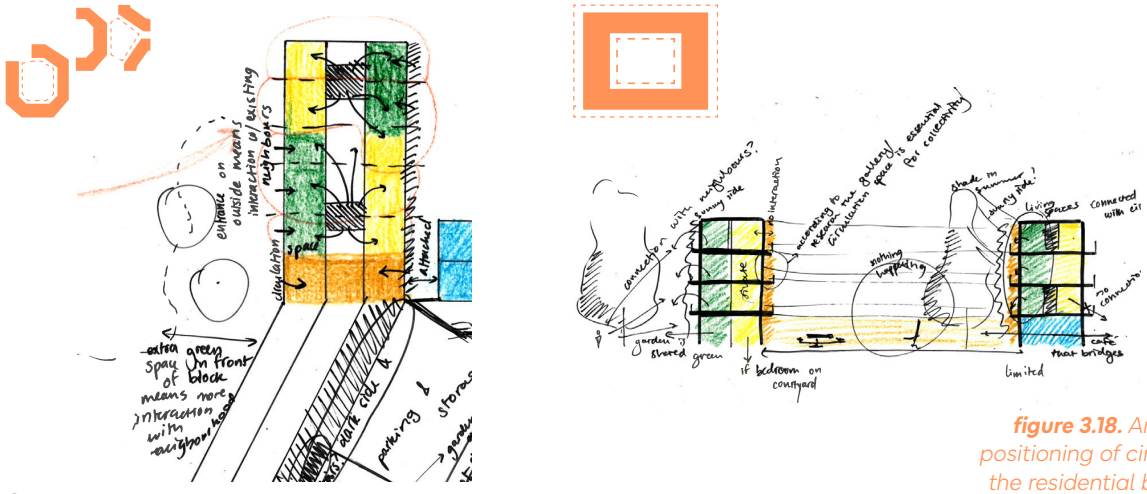


figure 3.20.

figure 3.18. *Analytical sketches of positioning of circulation space with the residential block. Author's work..*
figure 3.19. *Axonometrical volume studies, where the purple shows the shared spaces. Author's work.*
figure 3.20. *Plan drawing of the open courtyard and it's connection with the conext & section drawing of gallery showing enclosed outside space. Author's work.*

case study analyses and testing (cont.).

co-living analyses & testing.

The selected 'co-living' typologies provide different design principles depending on the typology. For example, for the guest house typology, these are: the building being low-rise, the volumes being spread out over the plot (with a shared, ground-floor, outside space), the façade being human-scaled, and the roof being pitched. These principles in some cases overlap, like the presence of a shared outside space on the ground floor, but in others differ, for example, with the gallery typology due to the volumes being collected into one big block, as opposed to being spread out. For more detailed information, see Appendix C. For clarity, the typologies have been simplified into the diagrams (Figure 3.21.).

The three selected typologies were then projected onto the site and compared in volume, floorplan and section studies. Due to the nature of the courtyard typology, this typology had two variations: the 'open' and 'closed' courtyard. These projections served as initial design massing studies for the future design proposal. When testing the different typologies, all seemed to have positive and negative outcomes (described in Appendix C). For example, with the gallery, flexibility is easier due to the circulation being external (not part of the grid), as opposed to the internally oriented circulation cores present in the courtyard or the guest house. An external gallery also allows for a dry passage from one block to the next, as opposed to walking through the outside, shared space. In the case of the guest house, having a shared space per building block allows for a better (& specific) ownership of these spaces, as opposed to it being central (and owned by everyone) in the courtyard typology. Or, in the open courtyard typology, improving the quality of living for the existing neighbours due to the additional 'open' green spaces, instead of being within the residential block and inaccessible to non-residents, like in the gallery typology. Therefore, there's not just one 'good' or 'bad' typology but rather a set of design principles that work well. The ones taken further into the prototyping phase are defined as follows:

- Covered circulation spaces allow for a more comfortable movement through the building and between buildings
- Shared spaces should be spread out over the plot and present in each building block, to improve ownership (and care), along with more moments of interaction
- There should be a clear definition between public, shared and private, to make sure different spatial needs are met within the block
- The residential block should have openings towards the existing neighbourhood to make sure the design is embedded in the urban fabric
- The volumes should be fairly rectangular to accommodate the 'open building' grid structure

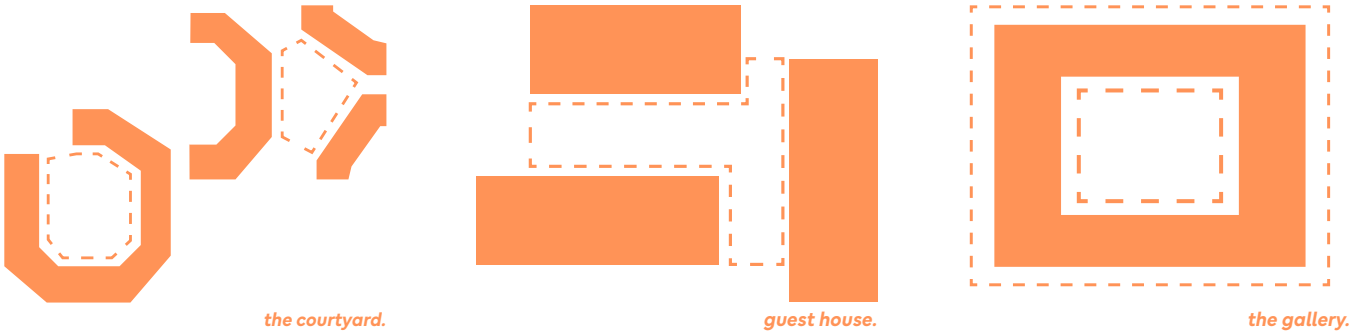


figure 3.21.

figure 3.21. *Typology abstraction diagrams. Author's work.*

integrated prototyping.

After gathering design principles through the literature reviews and case studies, the research goes on to integrate the lenses through different prototypes. These principles encompass physical & technical elements, and spatial elements. The latter have been defined through the co-living massing studies and the creation of personas (see Appendix A & C). These personas, and their spatial needs, are based on a set of rules that derive from literature studies described earlier (see Figure 3.27.)

With the definition of a 3.6x3.6m grid, an initial design prototype was developed. A design, implementing all households, was developed to determine the biggest pain points regarding this grid size (see Figure 3.22., 3.23 & Appendix E for further drawings). This design was then also compared to the personas spatial needs (in Appendix A) to understand which elements were specifically needed, in which were harder to implement. As expected with an initial prototype, there were many aspects that could still be improved. One of the main issues was that, in the households that were no more than one module wide (Haitao (a1) & Anaya (a2)), it was very hard to fit a bathroom & a kitchen along the length of the service shaft. Another issue was the width of space that remained within the shaft module. This limitation made either the circulation space around this room or the room itself very narrow, which meant that accessibility, especially for the elderly households, was very much restricted (Henriet & Piet (e2) or Erita (b3)). In this initial prototype, the outside space was also restricted to either the gallery balconies or the shared ground floor courtyard, not offering many options for people not wanting to be watched by their neighbours. There were also issues with the structural, façade and internal wall nodes. By placing the façade on the outside of the structure, if there was an offset in the façade or in the internal walls, there were 'odd' corners within the design (see figure 3.26.).

Having assessed the issues of the initial prototype, many seemed to be linked to the grid system, which meant that revisiting this choice was one of the next steps. After prototyping each cluster of household types (A through to E) within each of the six, examined grid sizes (see Appendix D for extensive tests), an argued choice could be made for the grid size that accommodated most residents' spatial needs (see figure for reasoning 3.28.). These prototypes mainly support the need for direction within the floorplan, while also supporting overdimensioning to have a slight spacing buffer within rooms and around the rooms. Therefore, a final grid of 3.7x4.05m was defined.

figure 3.22. *First fully developed design prototype, floorplan. Author's work.*
figure 3.23. *Part of the floorplan, depicting Anaya's household (type A2), and showing the lack of space for a kitchen & bathroom along the length of the shaft. Author's work.*
figure 3.24. *Part of the floorplan, depicting household type a2 & e2, and showing the width of either the bathroom or the corridor (with a bathroom. Author's work.*
figure 3.25. *Part of the floorplan, depicting 'odd' meeting points of the structure, facade & internal walls. Author's work.*
figure 3.26. *Section of proposed design, depicting the inner courtyard, showing the lack of diversity in the outside space.Author's work.*

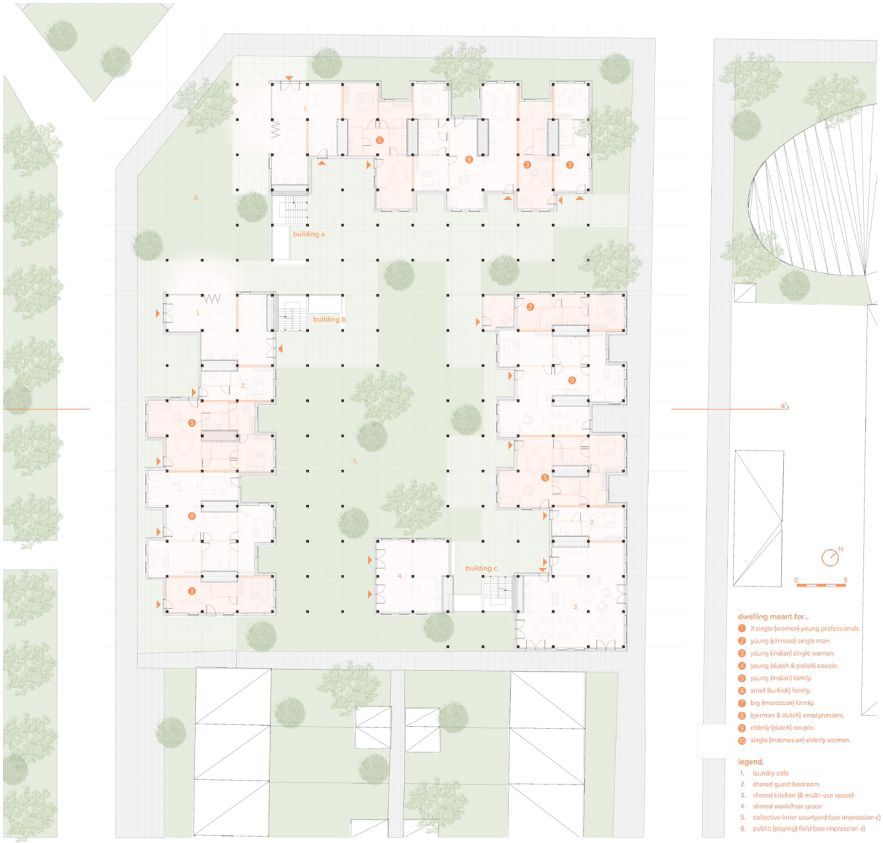


figure 3.22.

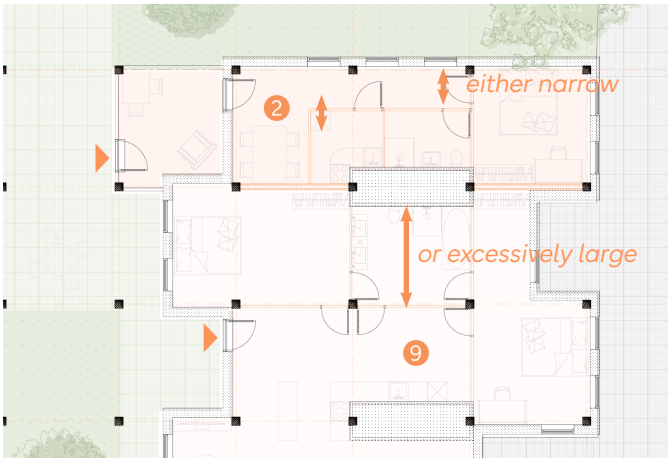


figure 3.24.

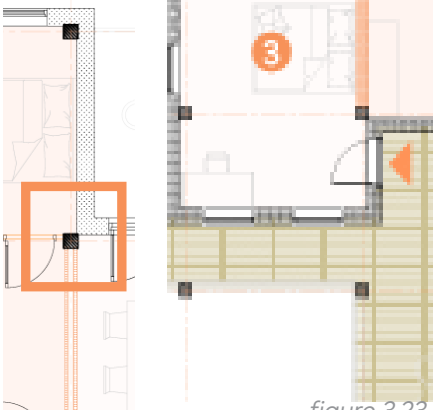


figure 3.23.

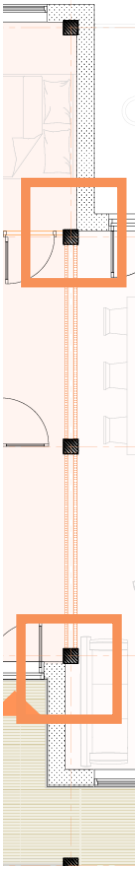


figure 3.25.

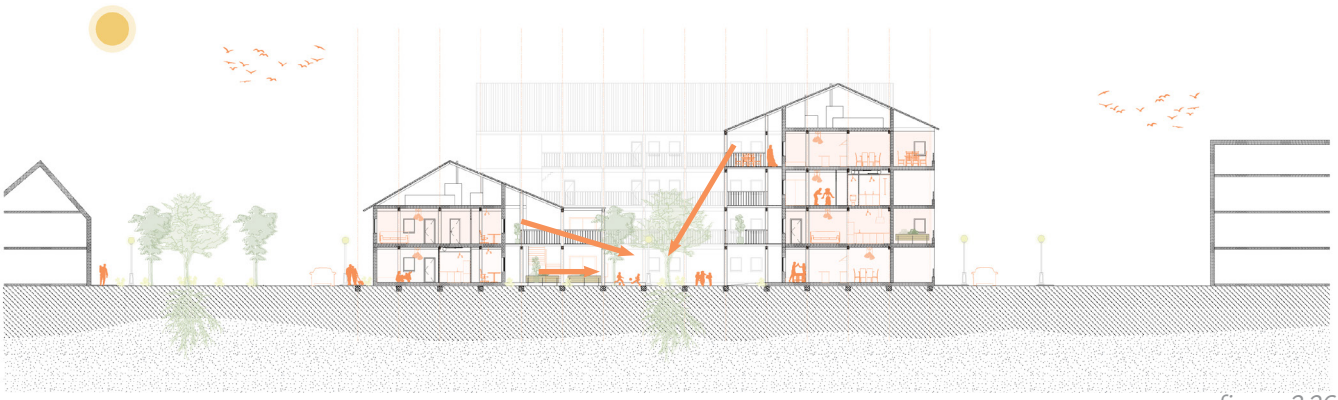


figure 3.26.

	household typology a.		household typology b.
	type a 1	type a 2	type b 1
			
	young (chinese) single man	young (indian) single woman	young (polish & dutch) couple
maximum m2	60 m²	35 m²	70 m²
(bed)rooms	min. 2 rooms, bedroom and living/dining room	studio room	2 bedrooms, 1 master one guest/home office
kitchen	kitchen in a seperate room	kitchen has an open wall to dining space	kitchen is partially open, due to smells
outside space	veranda space or courtyard is preferred, can be shared	attached to kitchen, can be shared	terrace or balcony
extra spaces?	veranda space, edge between in- and outside, potentially a guest room (can be outside own house)	guest room for family visiting, a shared office space or a neighbours meeting space	home office is preferred, but can also be the guest bedroom or future baby room
special home arragements	people can't walk straight into the bedroom or living room, there must be a buffer zone (also for shoes)	outside space attached to kitchen	big windows, and kitchen must be able to air through

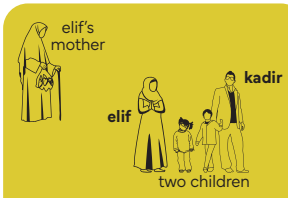
	household typology c.	
	type c 1	type c 2
		
	small (turkish) family	3 single (european) young professionals
maximum m2	100 m²	100 m²
(bed)rooms	3 bedrooms (1 master, 2 smaller)	3 bedrooms of equal size min 3x3m, 9m²
kitchen	kitchen is closed & connected to outside	open kitchen plan
outside space	preferred to have a garden or an inner courtyard	terrace or balcony, but can be shared
extra spaces?	no need for a home office, might need space for family or grandparents in the future	storage space is nice due to small bedrooms
special home arragements	two floors preferrably (downstairs is private and connected to a garden or courtyard, but has the kitchen, storage & guest space; upstairs has the living room and bedrooms)	big open living room, to also invite guest for dinner or parties, seperate toilet from bathroom

figure 3.27. *Defined household typologies and their associated personas that have been defined for further design explorations and the final design proposal. The associated colours come back in all the final drawings, and are used as a guiding theme throughout the drawings of the final design. Author's work based on literature research described earlier, and based on the set of rules defined on page 28, in figures 2.4. & 2.5.*

type b 2



young (indian) family

80 m²

min. 2 bedrooms, 1 master one baby/guest room

kitchen in a seperate room

balcony or terrace, attached to kitchen or dining room

home office is a must, a guest room for family is preferred can be outside of the house

outside space attached to kitchen, child daycare is preferred, inner courtyard connection

type b 3



single (indonesian) elderly woman

60 m²

1 bedroom with ensuite bathroom

two separate kitchens, a wet for cleaning and a dry for storage & cooking

outside space, but shared is good for the connection

a guest room, outside the house for family visiting, shared spaces to connect with neighbours

can be in two floors, but important part is to have a clear separation between the public (living, guest & kitchen space) and the private (bedroom & bathroom)

household typology d.

type d



big (moroccan) family

150 m²

5 bedrooms (2 master, 3 smaller)

kitchen is open to dining room

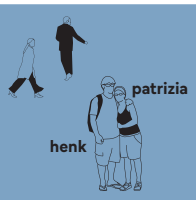
private courtyard that encloses the rooms & terrace?

preferrably one extra bedroom for guests, seperate living from dining room

more than one floor, and privacy on floors where public looks in (small windows or just walls), the inner part of the house is open and rooms are on the sides

household typology e.

type e 1



(german & dutch) emptynesters

90 m²

2 bedrooms (1 master with ensuite bathroom, 1 smaller)

open kitchen plan

outside space oriented on the sun, balcony or garden

seperate toilet, guest room in the house and maybe more outside the house

seperate toilet from bathroom, spacious living & dining room for (dinner) parties and family visiting

type e 2



elderly (dutch) couple

90 m²

2 bedrooms (1 master with ensuite bathroom, 1 smaller)

open kitchen plan

outside garden, oriented on the sun is a nice-to-have

seperate toilet, guest room in the house (and more outside), places for interaction with neighbours

seperate toilet from bathroom, spacious living & dining room for (dinner) parties and family visiting

	type a households.	**type b** households.	**type c** households.	**type d** household.	**type e** households.
3x3m adaptive co-housing.	desk space/work space is hard to fit in the shaft is too small to add all utilities (like toilet)	grid is too limiting to fit the different types of spaces with the square meterage	bedrooms have to be at least 2 grid sizes (which takes up a lot of space)	the master bedroom becomes very tight (even with two grid sizes) living room is too small for the family	small grid size allows for good seethroughs from facade to facade 1/2 grid too small for toilet space
3x3.8m + 3x2.2m quinta monroy.	kitchen (dining) table is very much squeezed the shaft is too small to add all utilities (like toilet)	the shaft is too small to add all the utilities needed	bedrooms become too small, and don't fit a working desk in the shaft is too small to add all utilities	the shaft is too small to add all utilities (like toilet) bedrooms (master & kids) become crambed	guest room/home office is very much squezzed within this grid
3.6x3.6m laan v/d vrede & modulus matrix.	✓ **best option**	✓ **best option**	bedrooms are still too small to have a working space inside them (the grid does facilitate working space in the living room)	kitchen can't be semi-open, dining table doesn't fit in one grid size desk doesn't fit in 1 grid size bedroom	✓ **best option**
3.6x3.8m san riemo.	kitchen (dining) table is very much squeezed the shaft is too small to add all utilities (like toilet)	✓ **best option**	slightly too small bedrooms but it's doable to have a desk in there	✓ **best option**	second toilet is either too big, or bathroom too small some odd (narrow) corners with non-symetrical grid
3.8x4.2m la borda.	✓ **best option**	excesively big grid by having shaft in the middle, the outside space is relatively far away	✓ **best option**	grid can only really accomodate 3 bedrooms upstairs due the stair space courtyard more symbolic	✓ **best option**

figure 3.28.

synthesis of results within a design proposal.

Having integrated and compared different design principles through prototyping, the research proposes a synthesised design (see Appendix F for the full drawing set). Within a structural grid system of 3.7x4.05m, and a floor height of 3.3m, the design accommodates 10 different households (presented through the earlier-mentioned personas & their associated colours).

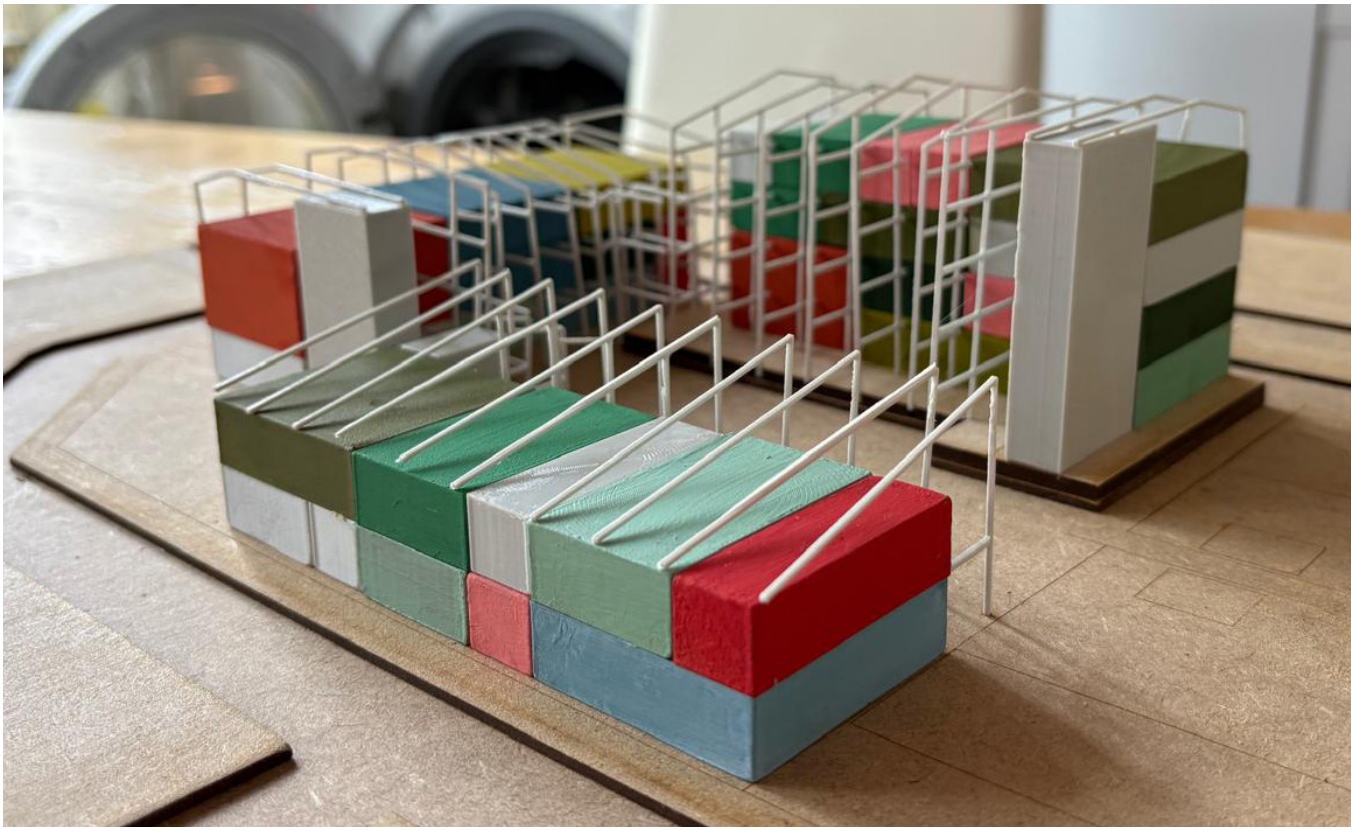


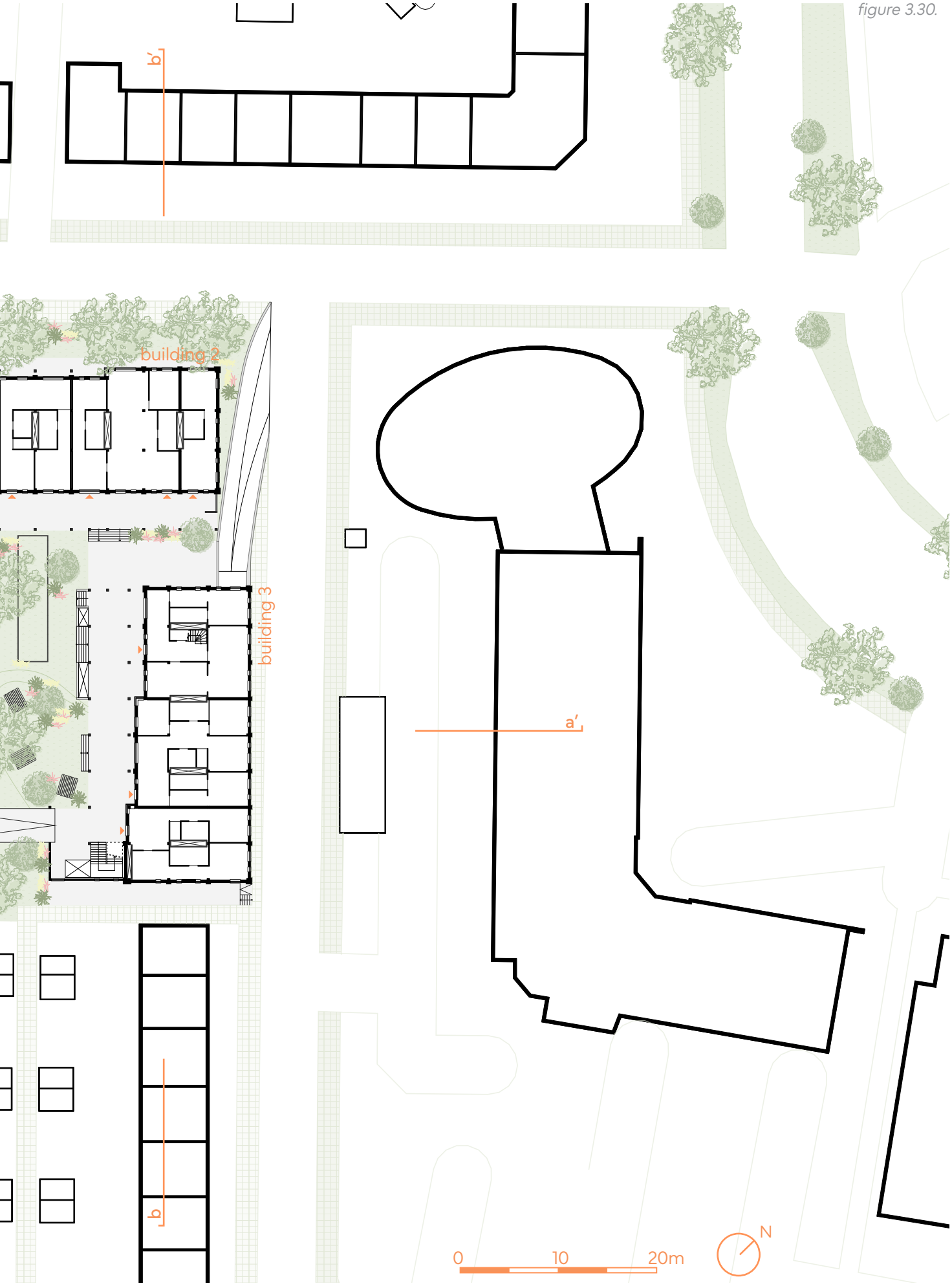
figure 3.29.

figure 3.28. *Summarised matrix of user & technologically integrated prototypes. Argues the choosen grid size for the design. Author's work.*

figure 3.29. *Picture featuring typological model of the proposed design (scale 1.250). The colours visible in the model are those associated with the previously described households. Author's work.*


a
building 1

figure 3.30.



synthesis of results within a design proposal (cont.).

The design finds itself on the edge of a 'bloemkoolwijk' and therefore becomes the transition between this typology and that of the high street (to the east). By working with inlets & offsets, inner & outer courtyard spaces, while increasing the volumes' grain size and implementing a modern 'guest house' site layout, it acts as a re-interpretation of the 'bloemkoolwijk' typology. To positively further its social & spatial impact within the existing context, the design adds qualitative outside space and neighbourhood-oriented facilities (through the playground in the outer courtyard, the 'wasbar', the outdoor picnic tables and the platform for performances within the shared living room). Within the outer façade, nudges towards the existing context are provided through materialisation and scale.

figure 3.31.



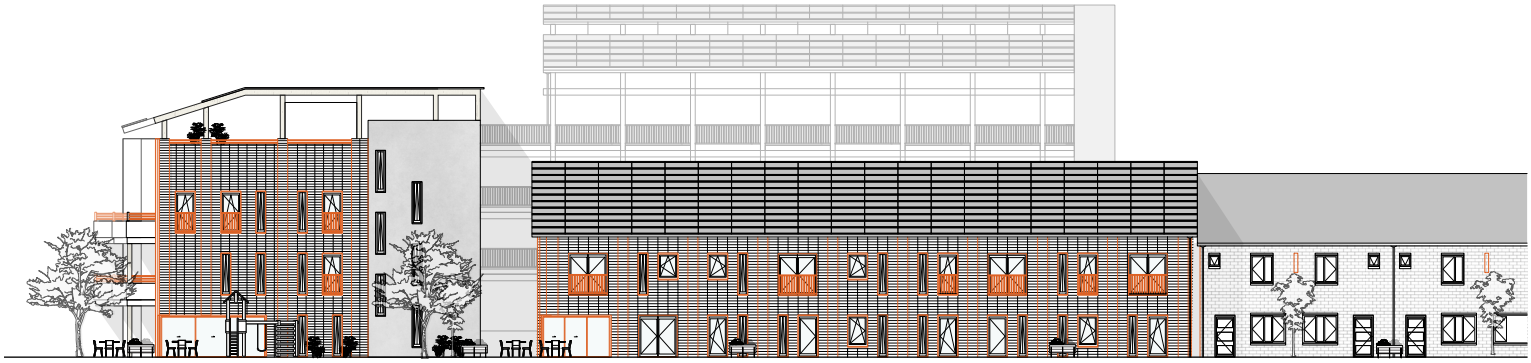


figure 3.32.

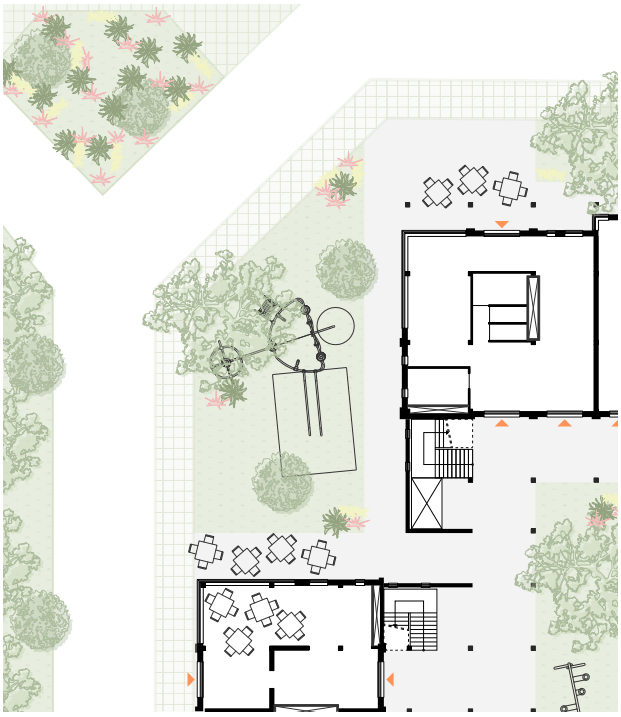


figure 3.33.

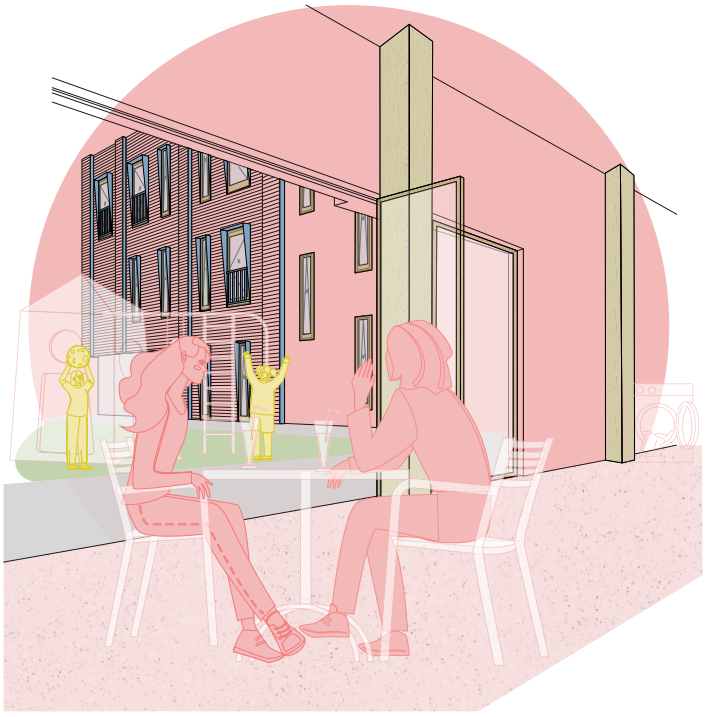


figure 3.34.

figure 3.30. *Site plan, of design at 1.500 scale, showcasing the outside spatial qualities. Author's work.*
figure 3.31. *Design embeded within the context of the 'bloemkoolwijk', scale 1.1000. Author's work.*
figure 3.32. *South façade placed within the context of the surrounding buildings, scale 1.200 (scaled to 1.400). Author's work.*
figure 3.33. *Zoomed in floorplan of the 'outer' courtyard with a playground attached to the laundry cafe and in connection with the existing neighbours. Author's work.*
figure 3.34. *Impression drawing of the laundry cafe, looking onto building 2.*
figure 3.35. *Zoomed in floorplan of the 'inner' courtyard with collective picnic tables & a swing.*

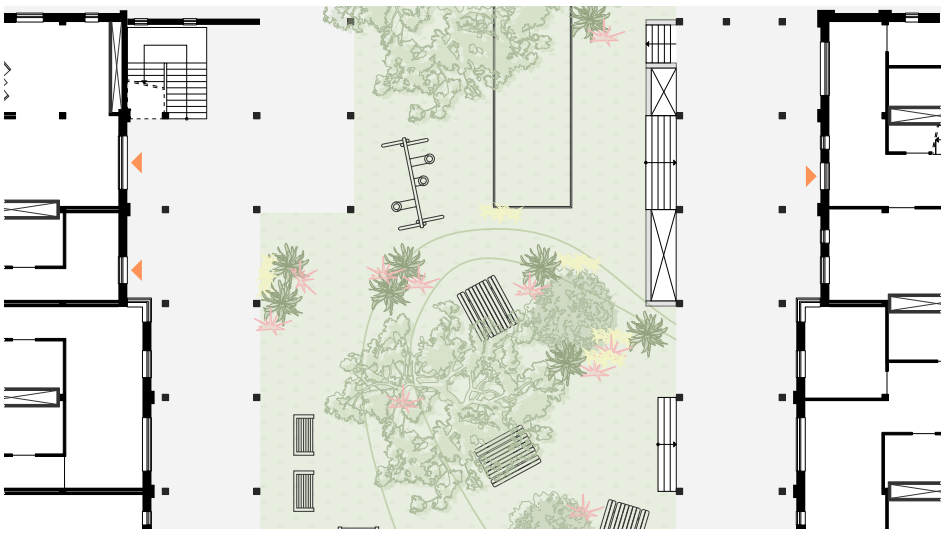


figure 3.35.

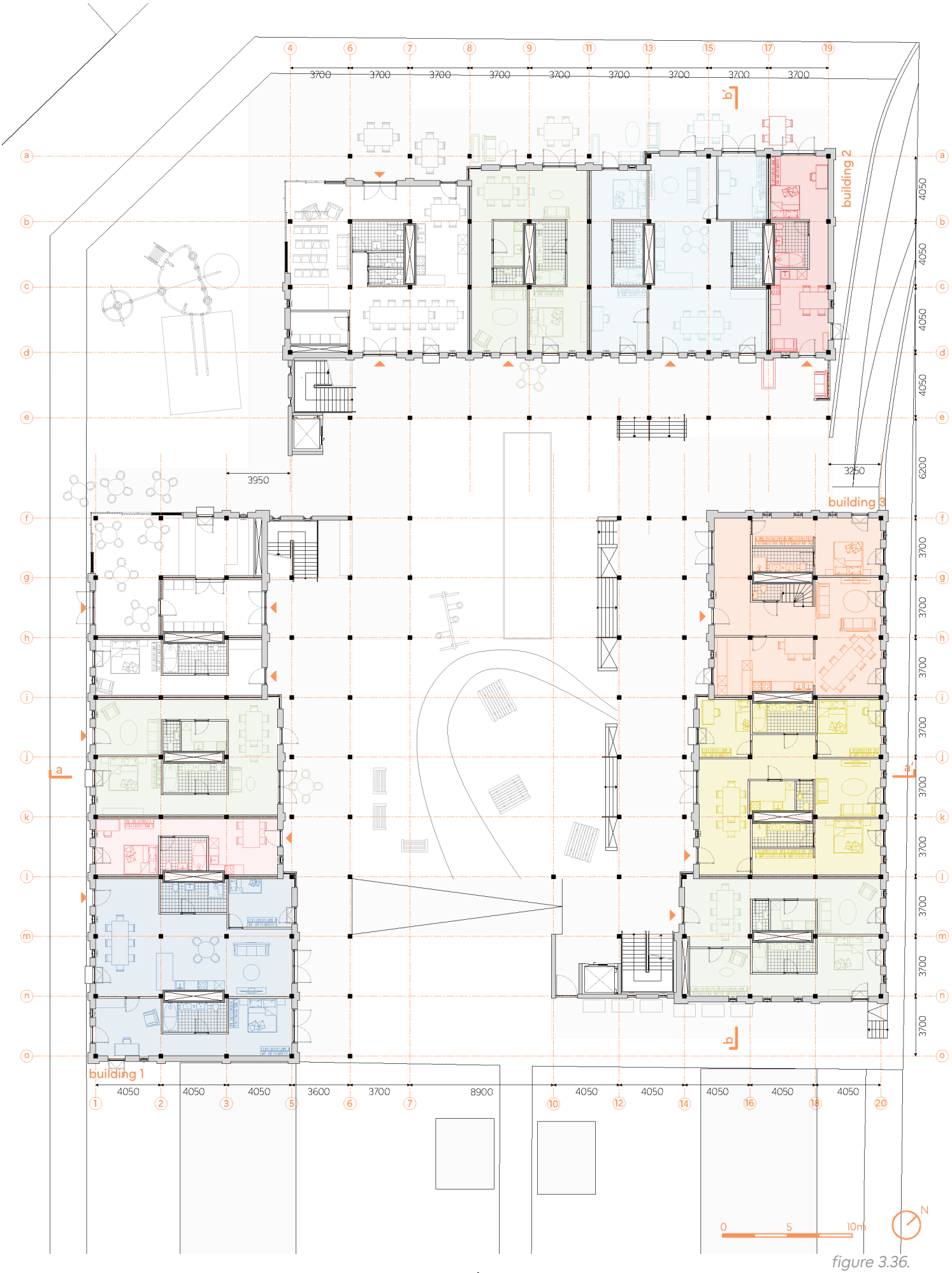

building 1
building 2
building 3
3700
3950
3250
4050
6200
3600
8900
0
5
10m
N

figure 3.36.

synthesis of results within a design proposal (cont.).

Zooming into the building scale, there are key architectural features that define the diversity within. At first glance, the most obvious elements are the different outside spaces. Within both the floor plans and the sections, we can identify public, shared, semi-private and private outside spaces. The public spaces (as highlighted earlier) are situated on the 'outside' of the residential blocks (see figure 3.36.); while the shared spaces are placed in between and at the top of the residential blocks (see figure 3.38.), creating a subtle barrier between these spaces and the surrounding neighbourhood. The semi-private spaces are an extension of the circulation galleries (see figure 3.37.), semi-privatised by a gap in the decking or an offset of the façade; while the private outside spaces are placed on the other side of the façade, in the form of balconies or back gardens (see figure 3.39.).

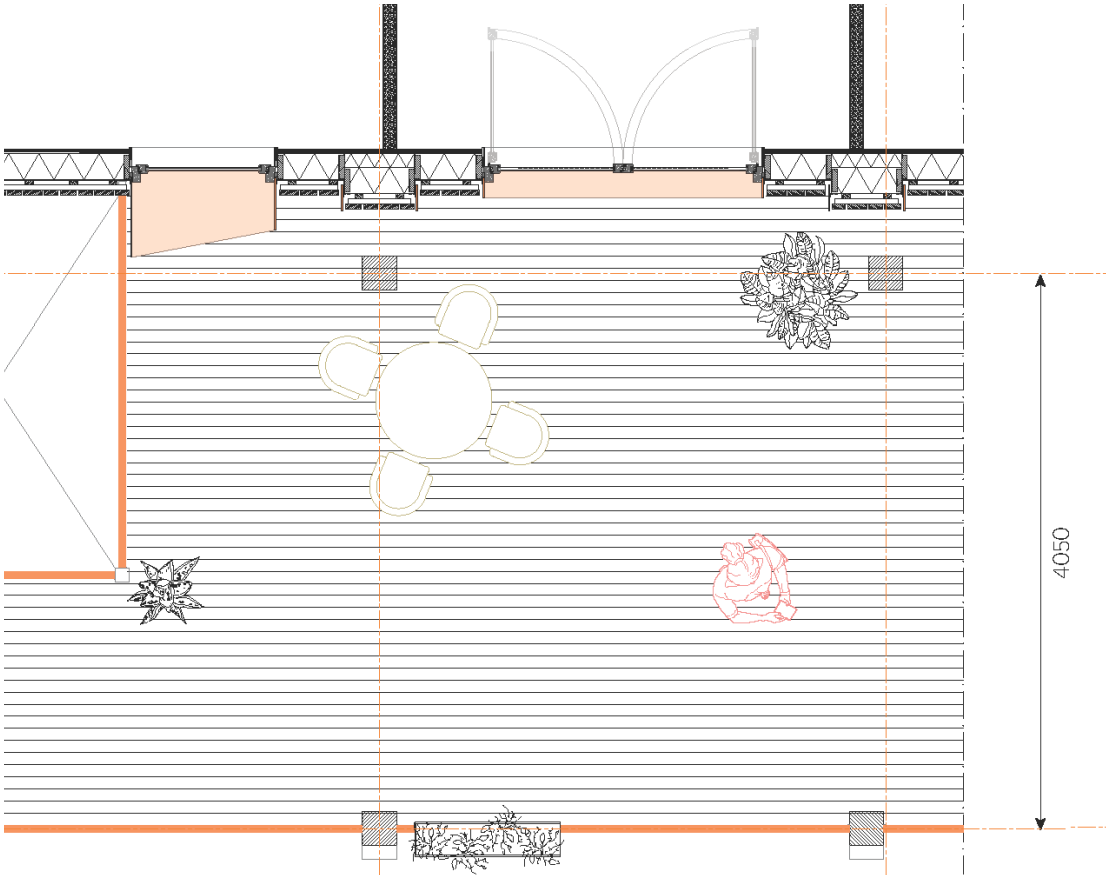


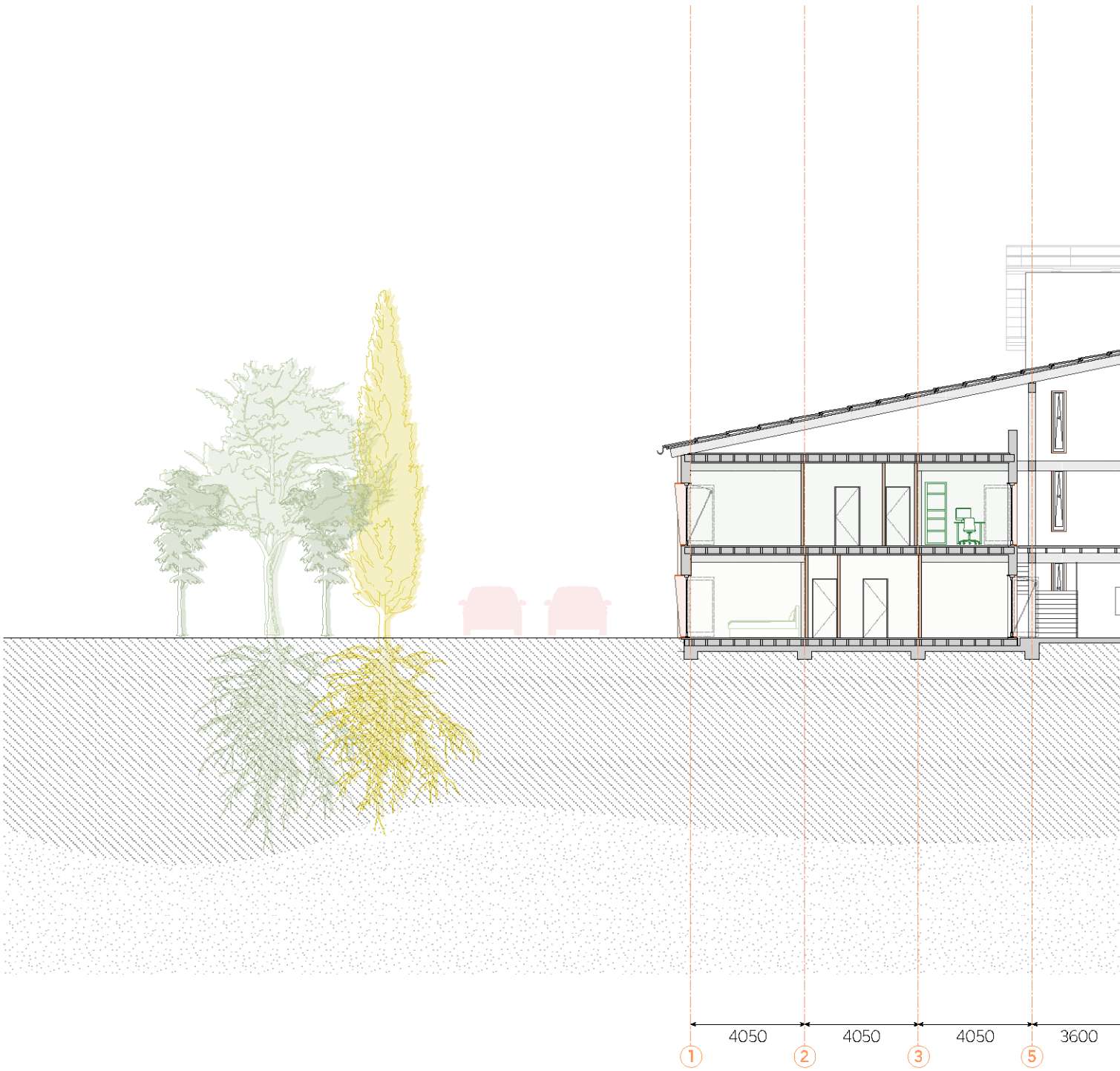
figure 3.37.

figure 3.36. *Ground floor with colours related to the household typologies, scale 1.200 (scaled to 1.300). Author's work.*

figure 3.37. *Horizontal façade segment, scale 1.60, showing the gallery and the bufferzone between the walkway & the house. Author's work.*

figure 3.38. *Section aa' showing the inner courtyard, scale 1.200, highlighting outside spaces. Author's work.*

figure 3.39. *Section bb' showcasing the different types of outside within the building (& how they can be used, scale 1.500. Author's work.*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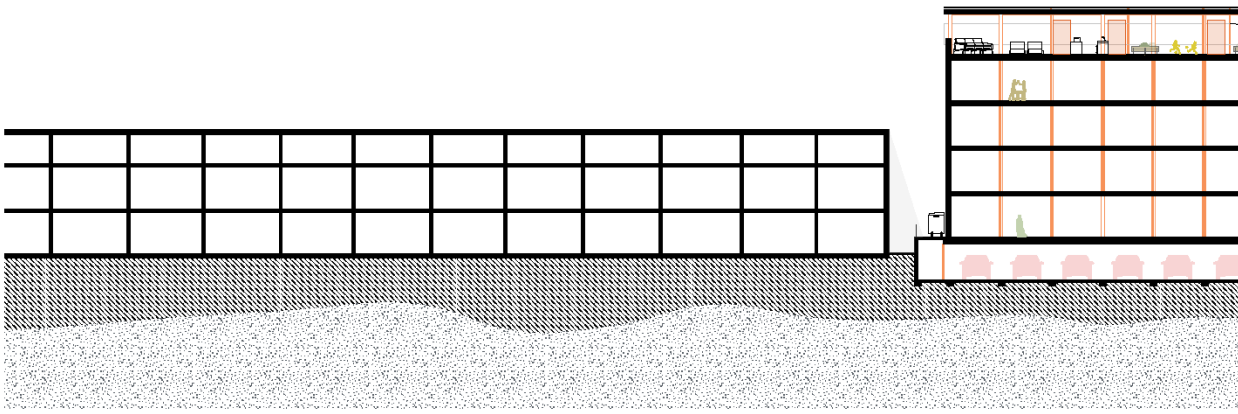


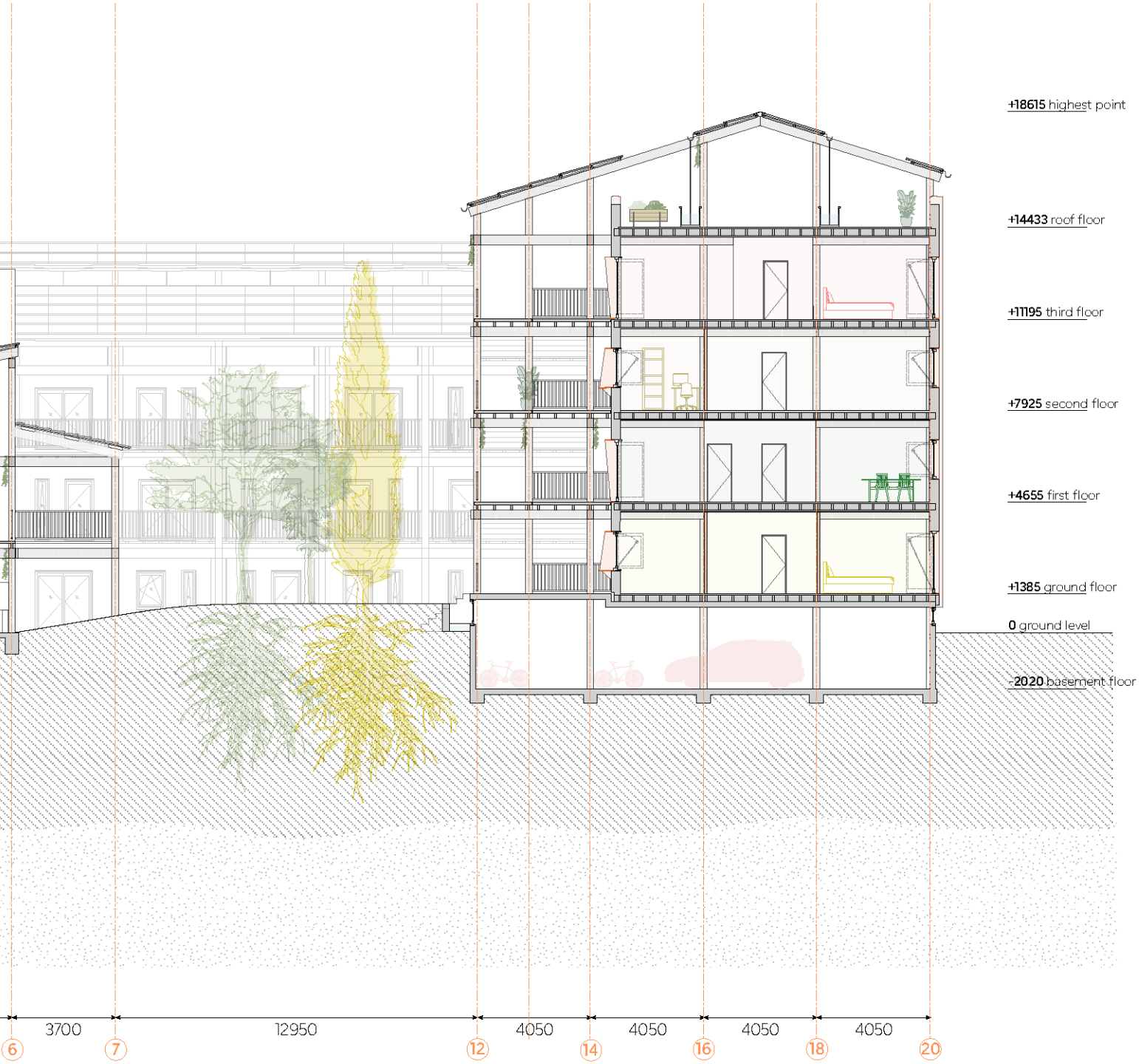


figure 3.38.

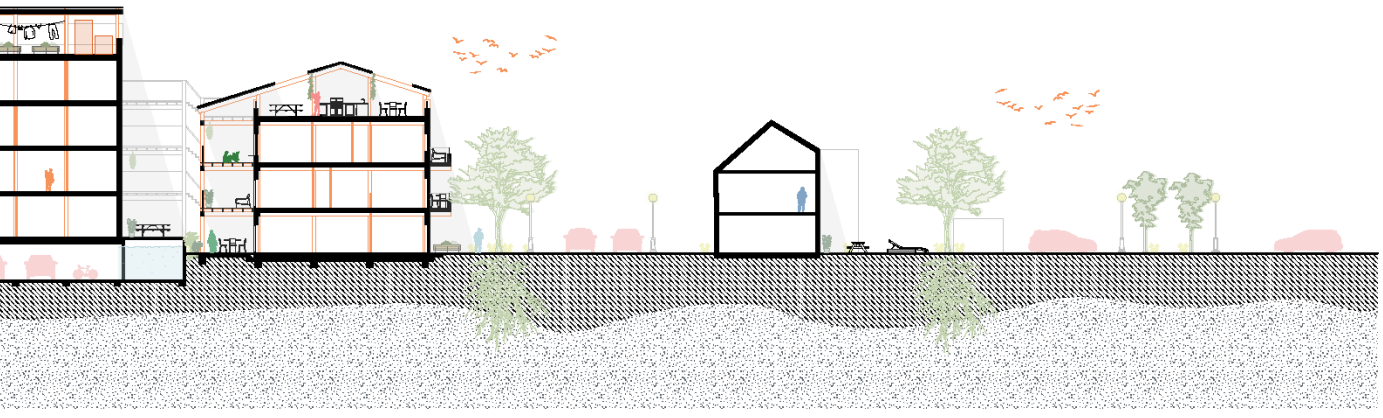


figure 3.39.

synthesis of results within a design proposal (cont.).

Due to each building within the residential block having its own type of outside space, and the mobility of each resident being different, the spatial organisation of the households within the whole block is also key. If we look at the family households (C1 & D), due to the children mainly playing outside, a view of either the playground or the inner courtyard (from the home) is preferred. As a Moroccan household, D very much values the presence of either a private or semi-private outside space. While household C1, being Turkish, might not have a strong opinion about this, the presence of a nearby guest room to host grandparents is important to them.

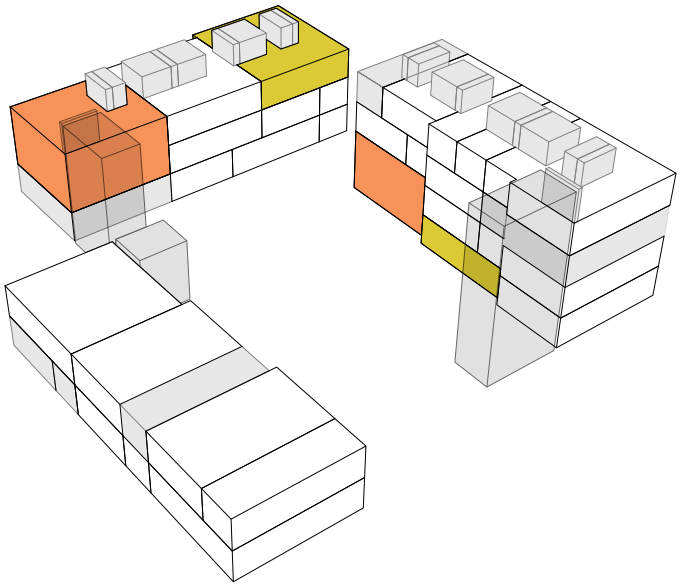


figure 3.40.

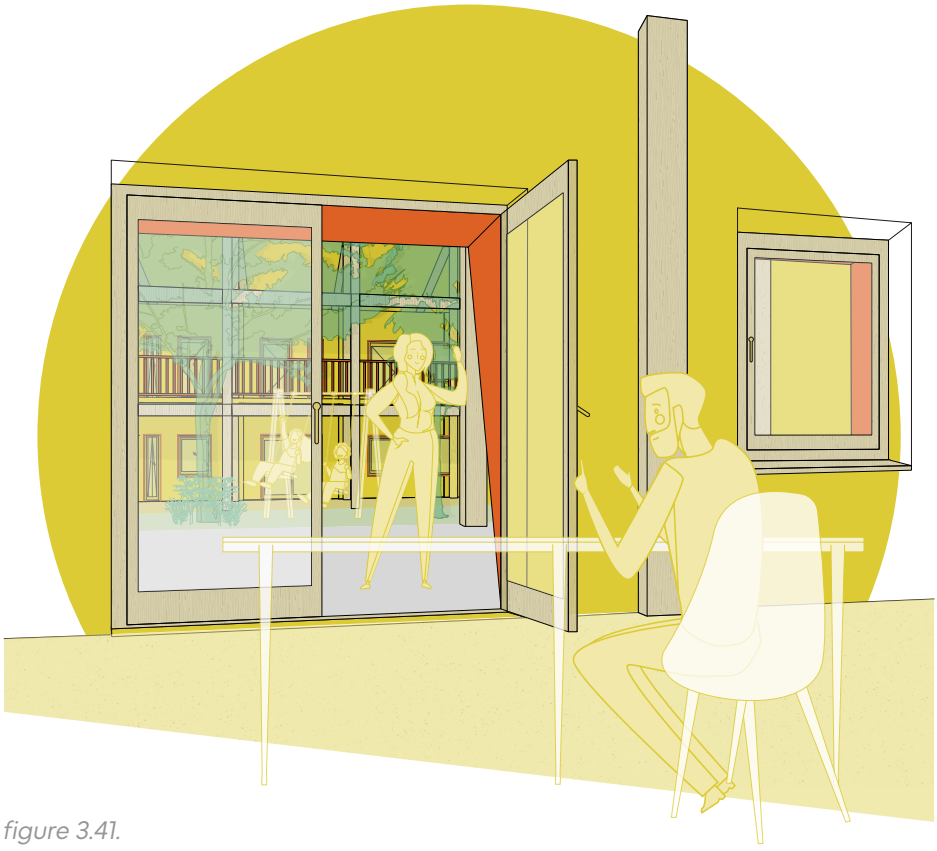


figure 3.41.

figure 3.40. *Axonometry highlighting households C1 (in yellow) & D (in orange). The shared spaces are coloured grey, Author's work.*
figure 3.41. *Impression drawing from the inside of household C1 on the ground floor. Author's work.*
figure 3.42. *Part of the floorplan, depicting household D & it's relation to the gallery as well as the type of outside space it has. Author's work.*
figure 3.43. *Part of section bb', identifying the (shared) guest room next to household C1. Author's work.*

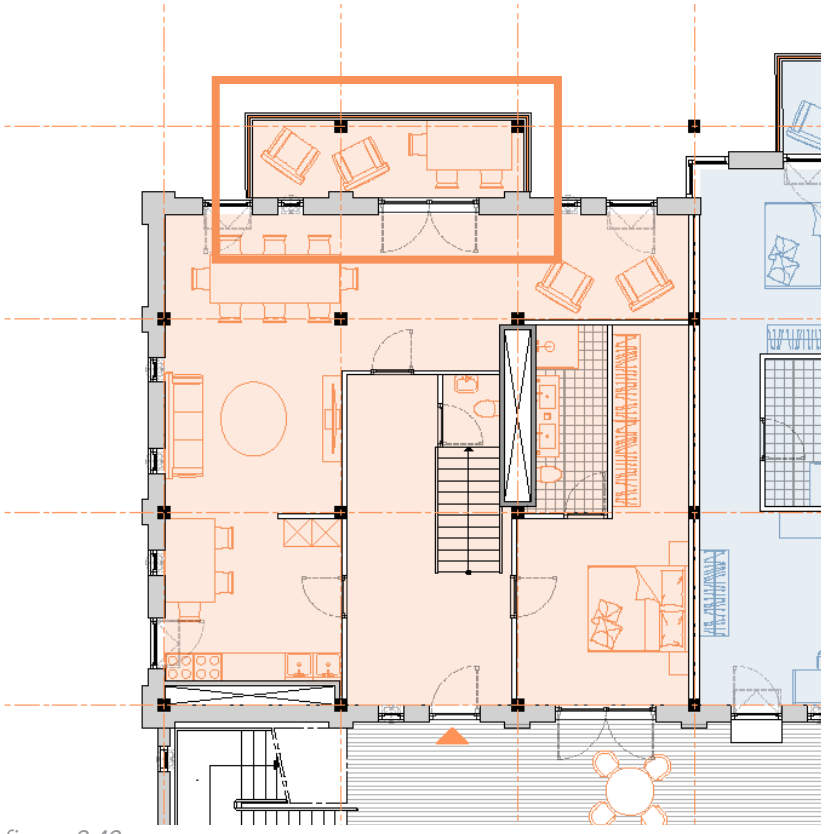


figure 3.42.

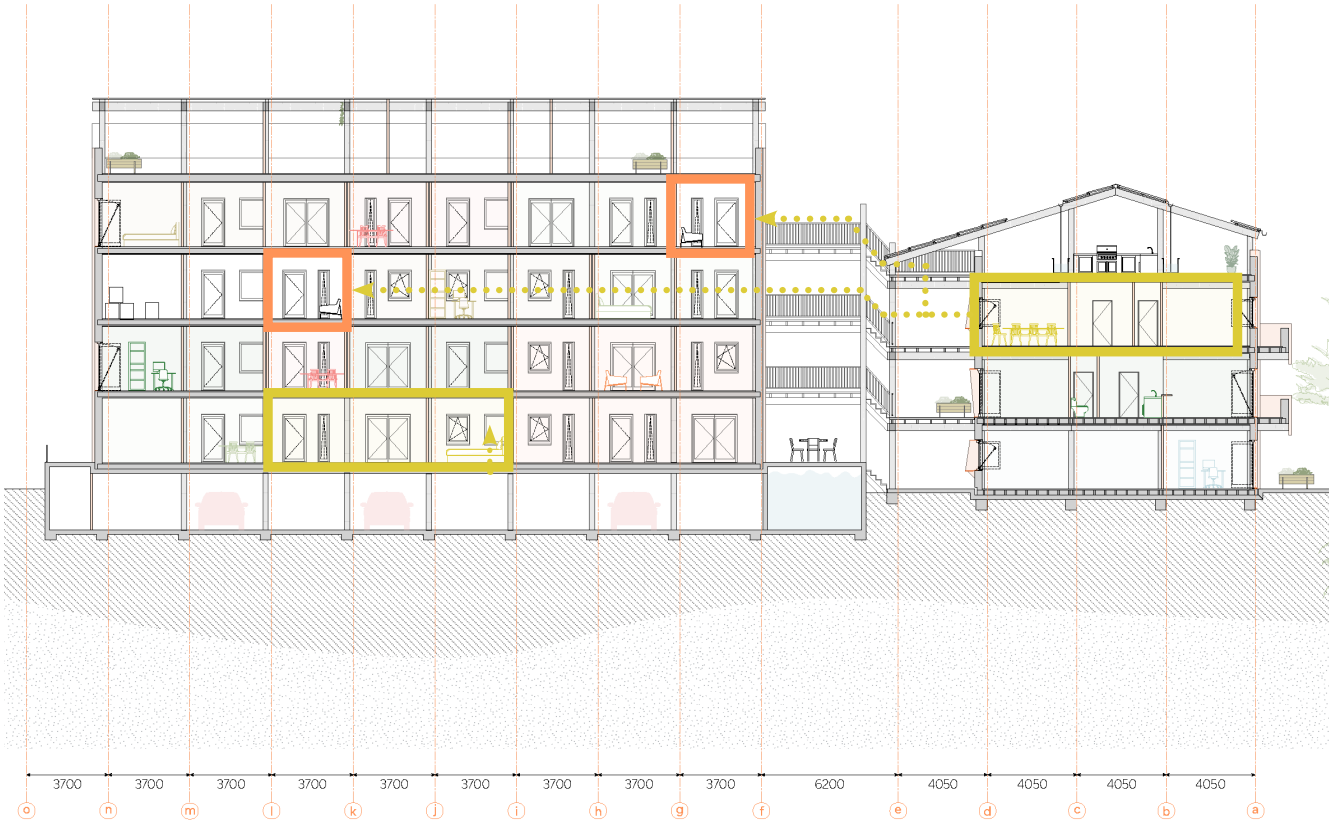
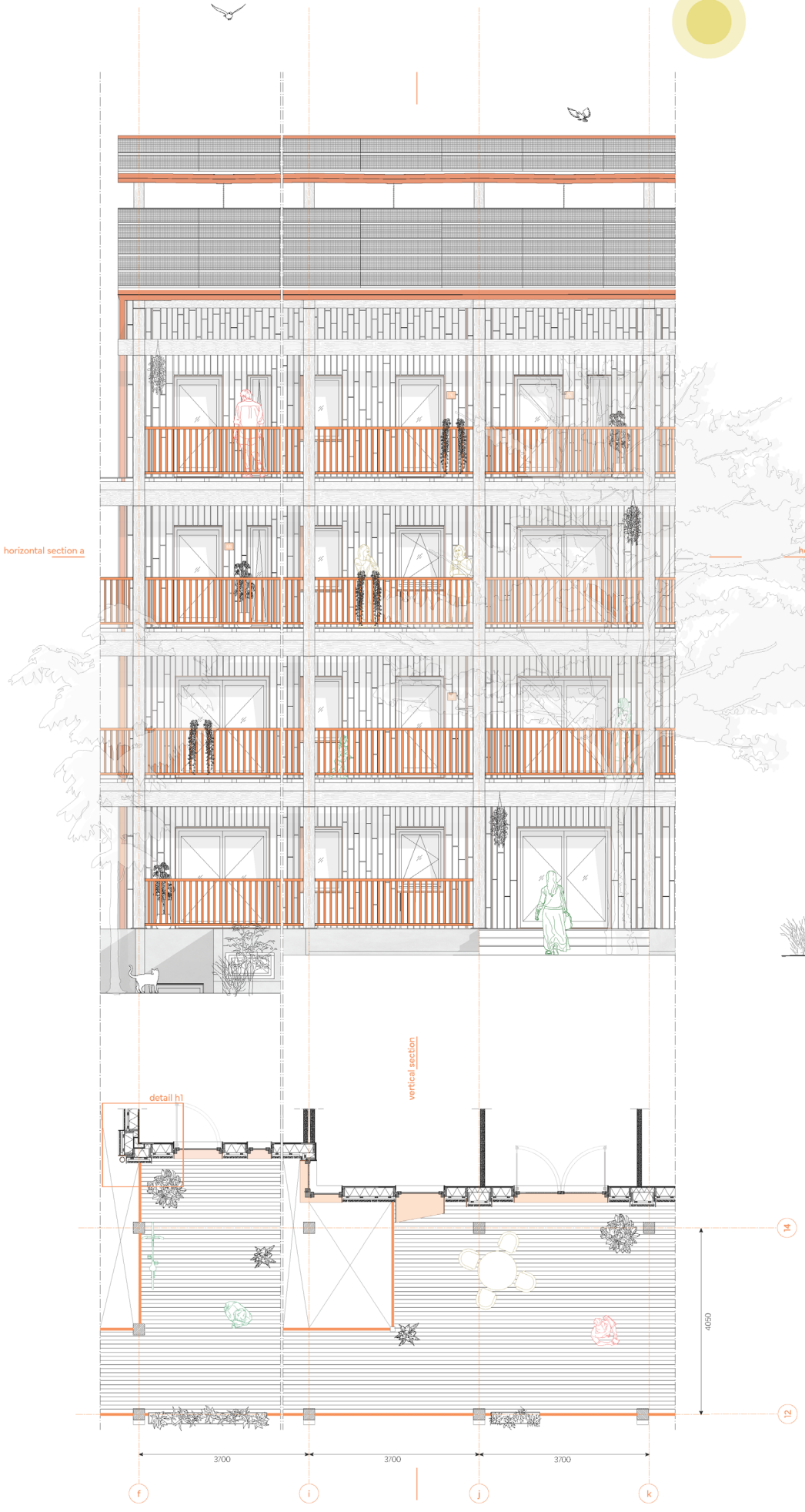
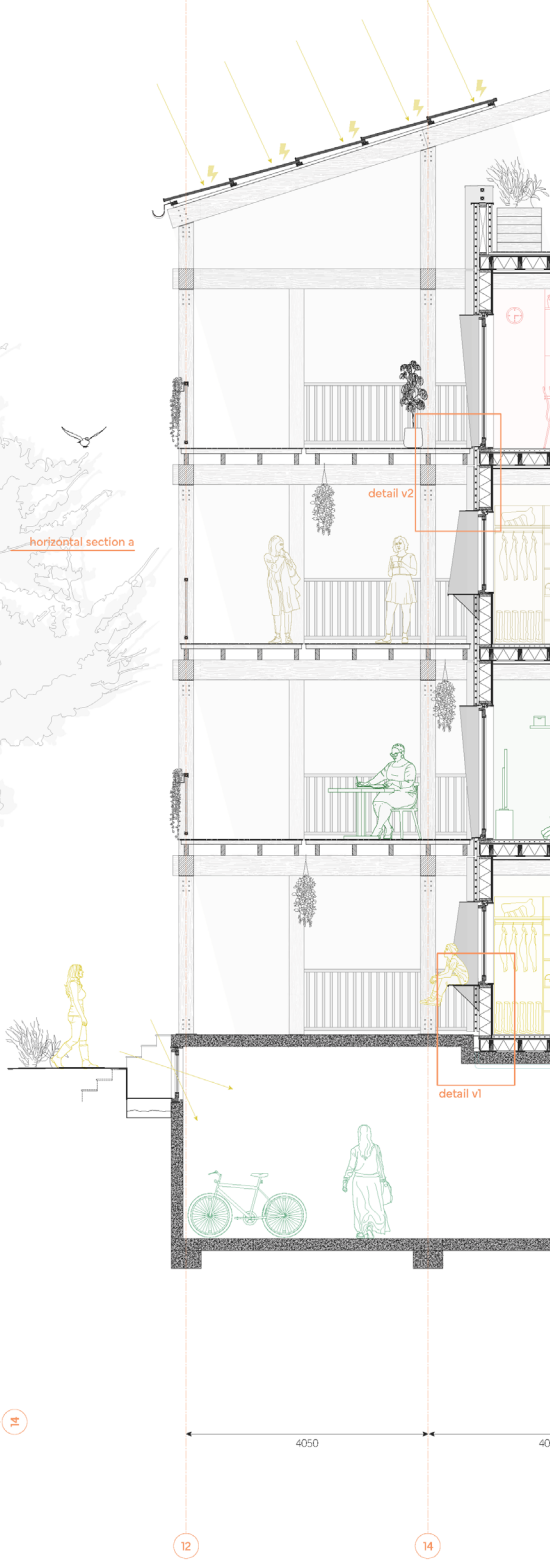


figure 3.43.



horizontal section a.



vertical section.

figure 3.44.

synthesis of results within a design proposal (cont.).

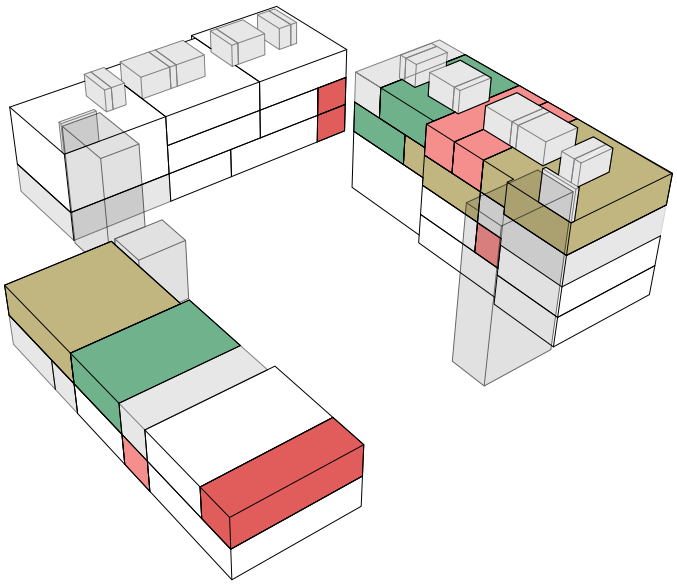


figure 3.45.

Due to the younger generations, households A1&2, B1 or C2, working most of the day, enjoying the evening sun (higher up in the building) is preferred. These households are also more likely to invite (bigger groups of) guests around, which makes the presence of shared barbecues and outdoor picnic tables in the courtyard or kitchenettes and dining tables on the roof terrace a perfect way to host people without needing too big a house. By placing these households in the buildings facing south & west, the seating options (on the gallery) provide a perfect spot to sit towards the end of the afternoon. As an exception, household A1, due to their Chinese background, also values the presence of a buffer between the 'outside' and the home, which is why this household is mainly placed at the end of the gallery so the buffer zone does not interfere with the circulation.

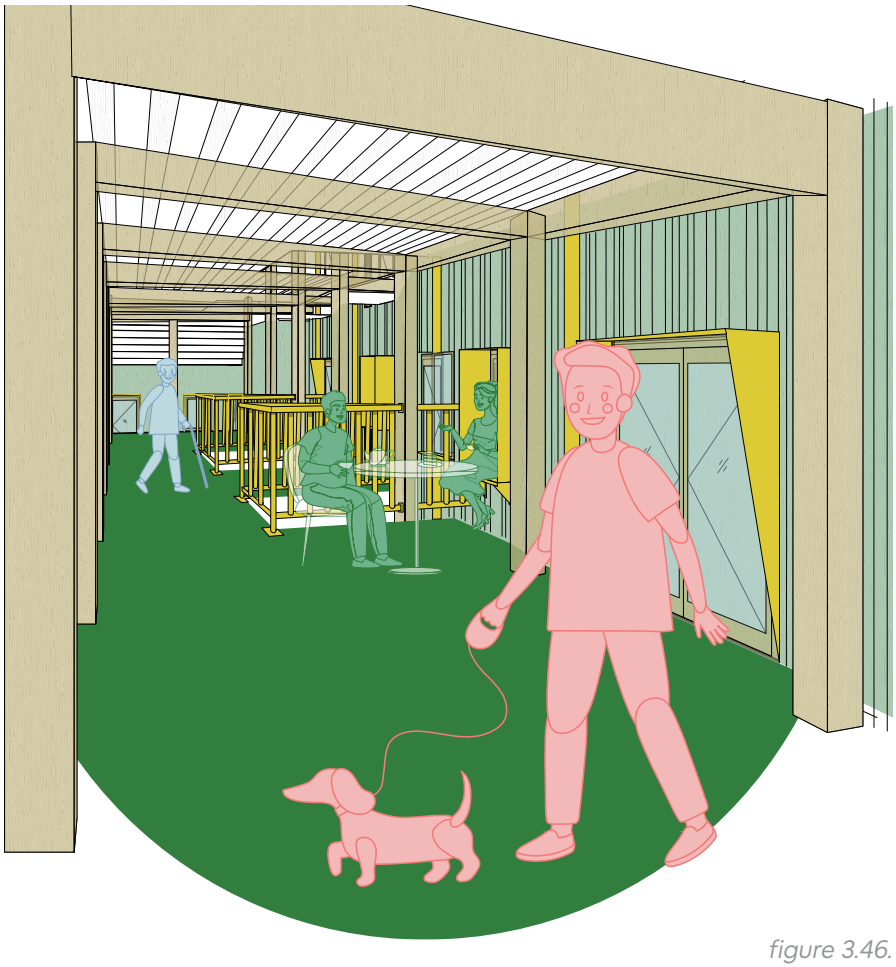


figure 3.46.

figure 3.44. *Façade fragment, of the interior façade cladded with wood and attached to the gallery, where the gallery also works as a form of sunshade & as a way of interaction. Author's work.*
figure 3.45. *Axonometry highlighting households A12 (in red), A2 (in pink), B1 (in green) & C2 (in brown). The shared spaces are coloured grey, Author's work.*
figure 3.46. *Impression drawing from the gallery, showcasing the seating in the facade. Author's work.*
figure 3.47. *Detail of seating element in façade, scale 1.5 (scaled to 1.10). Author's work.*
figure 3.48. *Detail of rooftop terrace, scale 1.5 (scaled to 1.10). Author's work.*

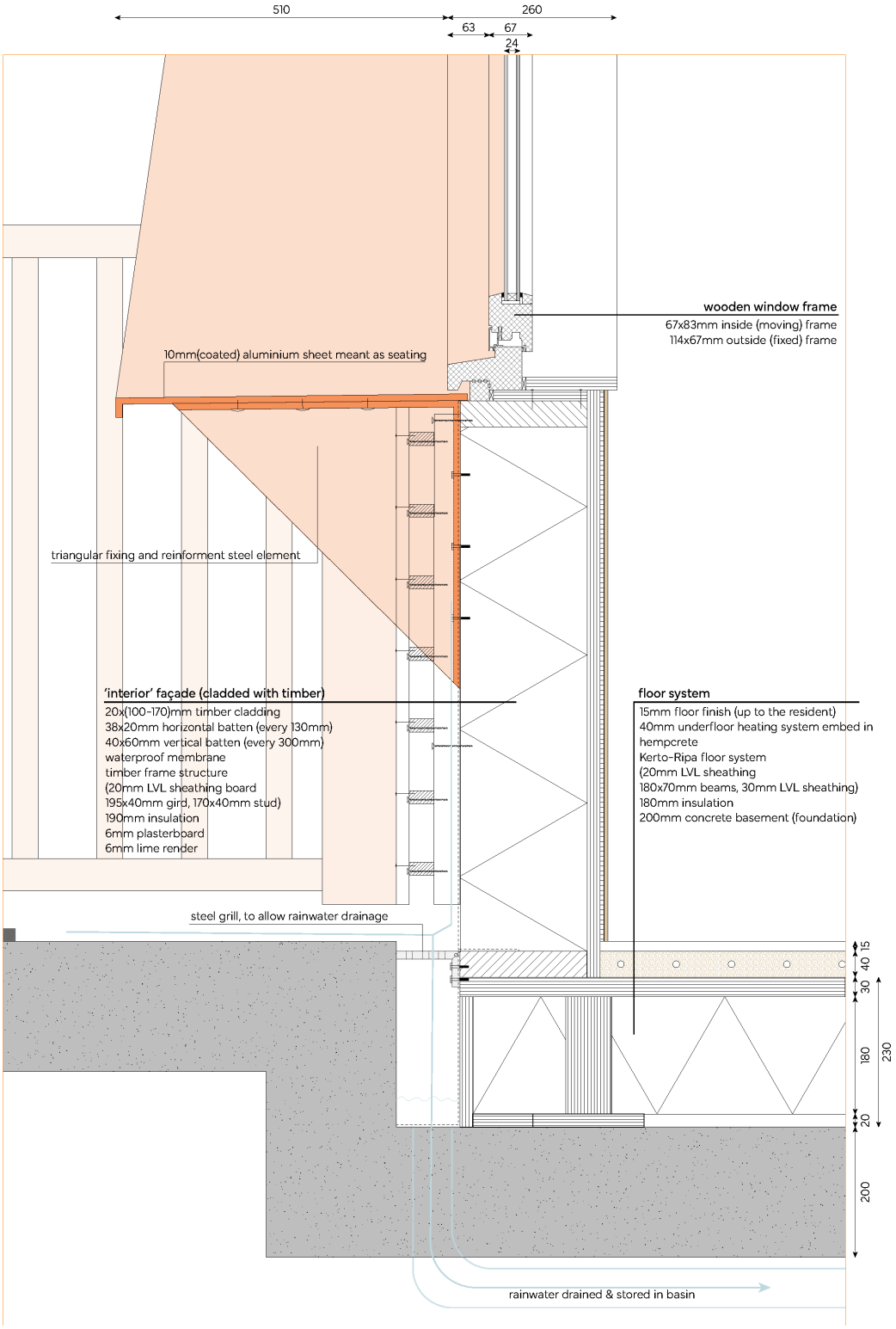


figure 3.47.

figure 3.49.

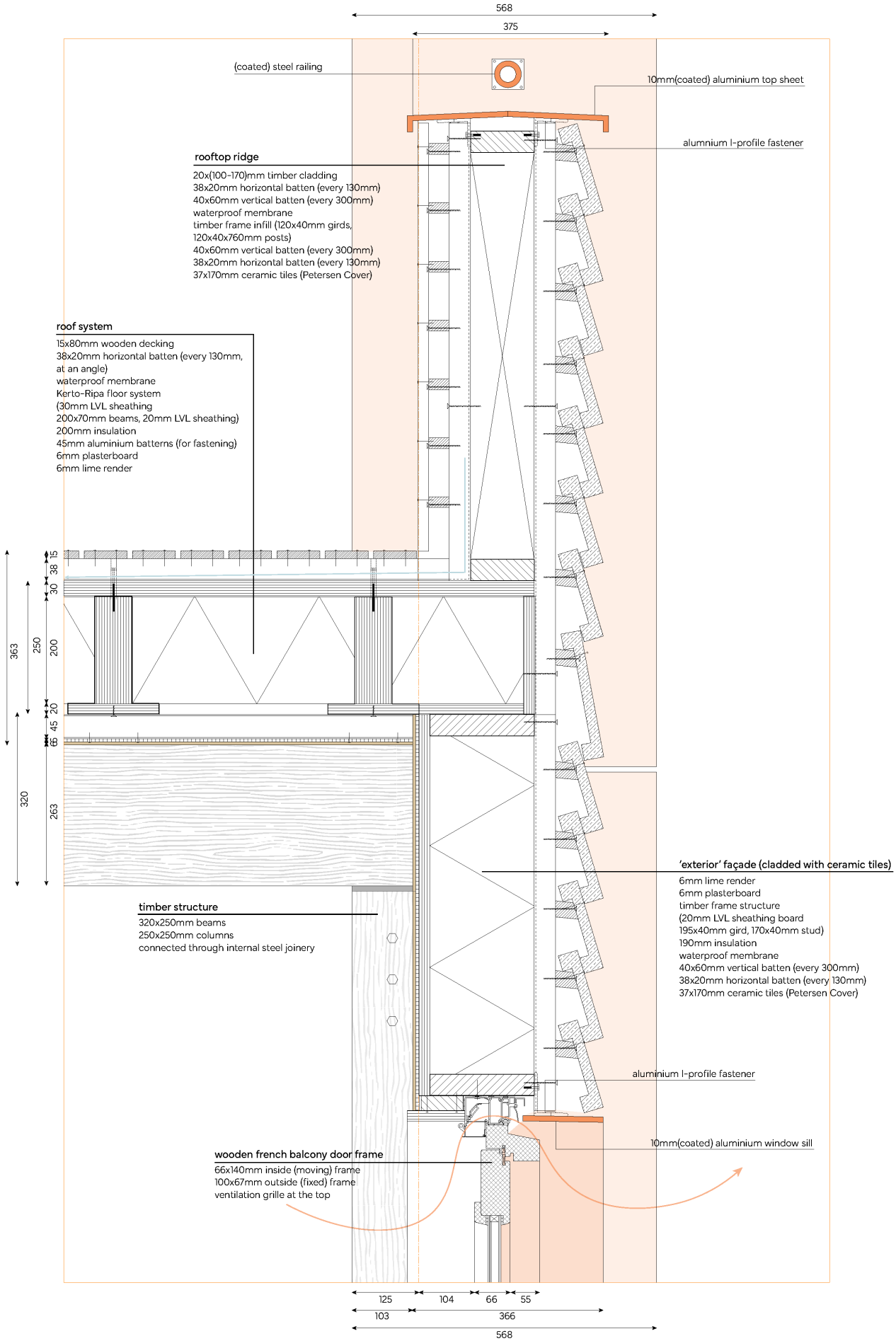

568
375
(coated) steel railing
10mm(coated) aluminium top sheet
alumnium l-profile fastener
rooftop ridge
20x(100-170)mm timber cladding
38x20mm horizontal batten (every 130mm)
40x60mm vertical batten (every 300mm)
waterproof membrane
timber frame infill (120x40mm girds,
120x40x760mm posts)
40x60mm vertical batten (every 300mm)
38x20mm horizontal batten (every 130mm)
37x170mm ceramic tiles (Petersen Cover)
roof system
15x80mm wooden decking
38x20mm horizontal batten (every 130mm,
at an angle)
waterproof membrane
Kerto-Ripa floor system
(30mm LVL sheathing
200x70mm beams, 20mm LVL sheathing)
200mm insulation
45mm aluminium batterns (for fastening)
6mm plasterboard
6mm lime render
15
38
30
200
250
363
20
45
66
320
263
'exterior' façade (cladded with ceramic tiles)
6mm lime render
6mm plasterboard
timber frame structure
(20mm LVL sheathing board
195x40mm gird, 170x40mm stud)
190mm insulation
waterproof membrane
40x60mm vertical batten (every 300mm)
38x20mm horizontal batten (every 130mm)
37x170mm ceramic tiles (Petersen Cover)
timber structure
320x250mm beams
250x250mm columns
connected through internal steel joinery
aluminium l-profile fastener
10mm(coated) aluminium window sill
wooden french balcony door frame
66x140mm inside (moving) frame
100x67mm outside (fixed) frame
ventilation grille at the top
125
104
66
55
103
366
568

figure 3.48.

synthesis of results within a design proposal (cont.).

For the elderly (households E1&2, B3), accessibility is essential. By designing floors that are flush with the site's ground level or with the gallery, the movement from the street or the gallery into the home is very smooth. Also, having a car park that is connected with each building floor by a lift allows people who struggle to walk or cycle to still move around. Within households E1&2, due to the Dutch and German cultural backgrounds, the presence of a private balcony or garden that faces the sun is very important since that is where they will spend a lot of time. The possibility to split the E1&2 homes into two is important for both the future change in household size or economic situation. On the other hand, for household B3, due to their Indonesian background, outside space is less important but the privacy of the bedroom, while having the space (inside the home) to host the family, is very important. If the house is placed close to circulation nodes, that would be the best, since it would mean more daily casual interactions with neighbours.

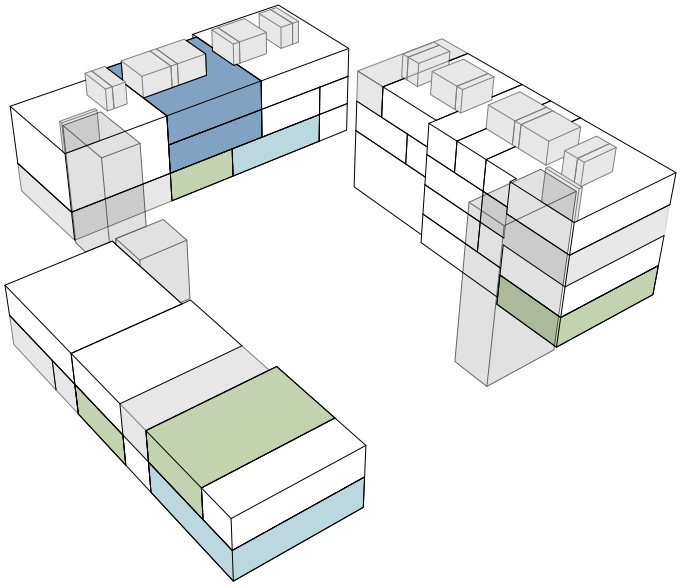


figure 3.50.



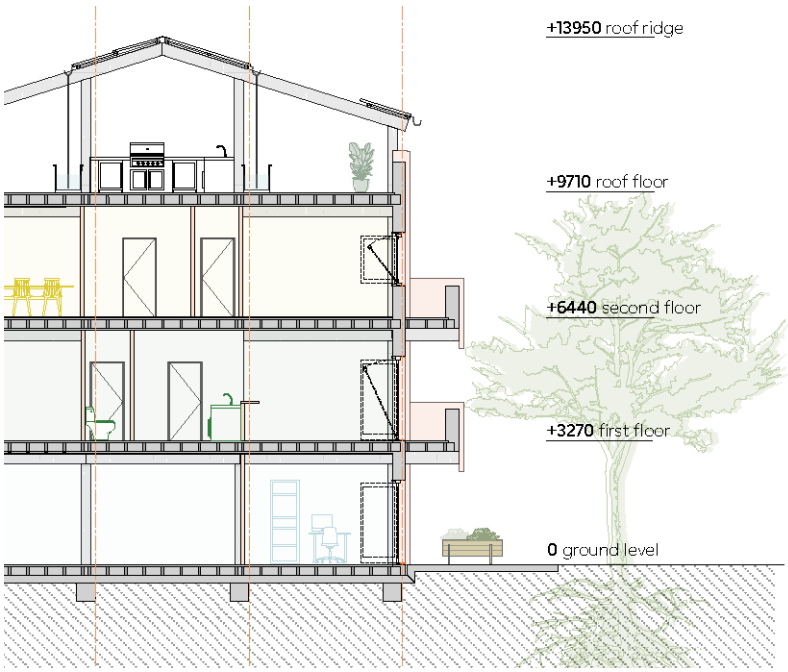


figure 3.49.

figure 3.49. *A section of Section bb', scale 1.200, indicating the the private balconies (see carpark in figure 3.38 & 3.43). Author's work.*

figure 3.50. *Axonometry highlighting households E1&2 (in blue) & B3 (in green). The shared spaces are coloured grey, Author's work.*

figure 3.51. *Detail of gallery to the facade, showing an almost flat transition from out- to inside. Author's work.*

figure 3.52. *Part of the floorplan, depicting household E2 & it's possibility to be split, due to the size of the house & the position of the service shaft. Author's work.*

figure 3.53. *Part of the floorplan, depicting household B3, showing the possibility for privacy while allowing for a big space within the living area to host people. See also the closeness to the lift & stairs for more interaction Author's work.*

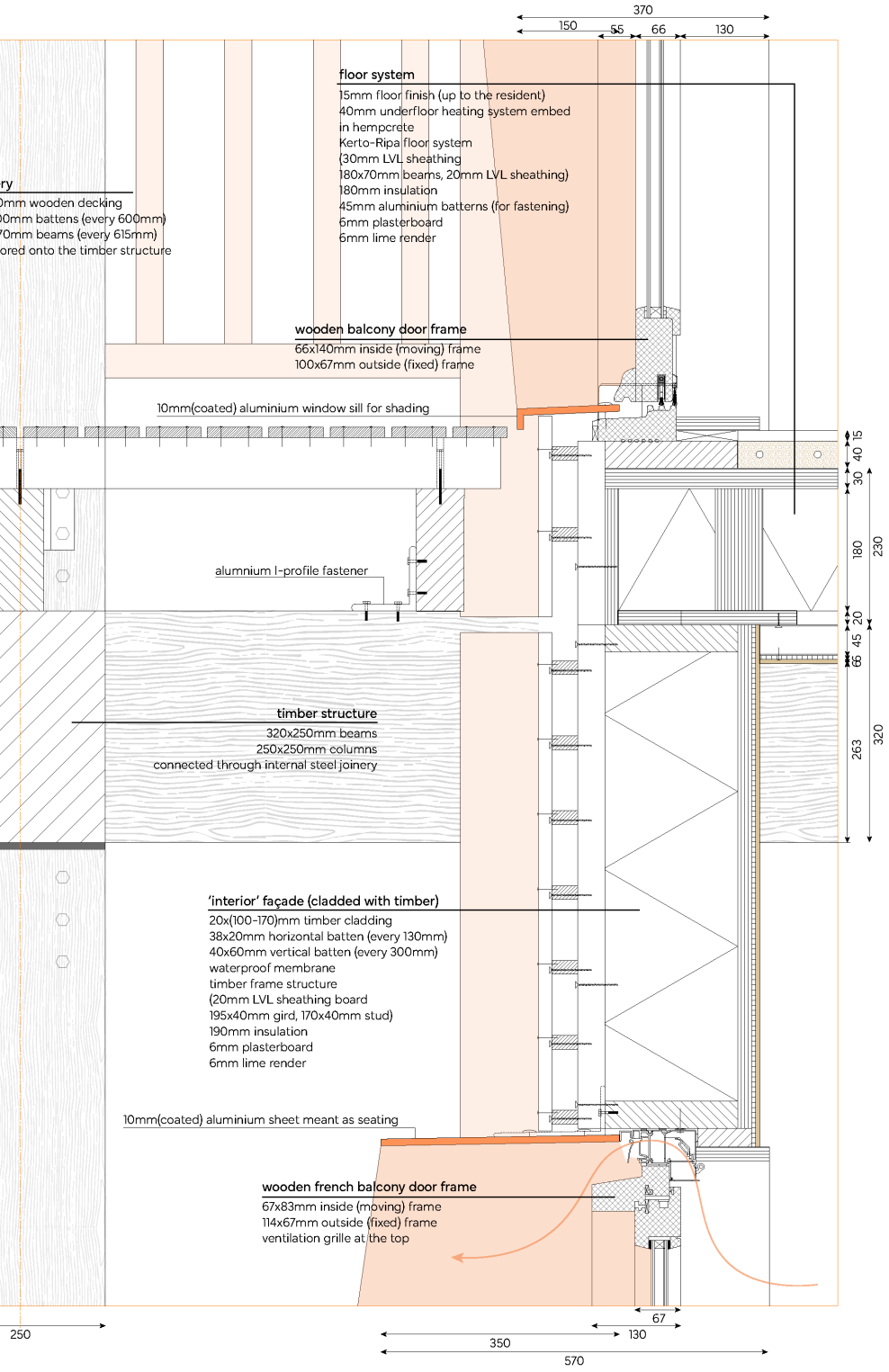


figure 3.51.

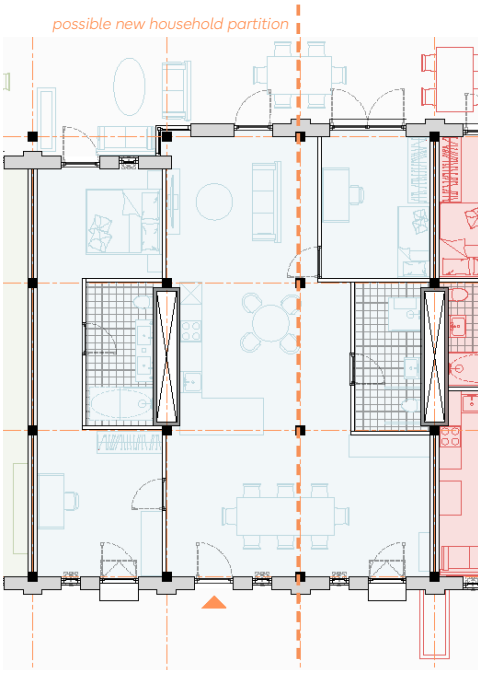


figure 3.52.

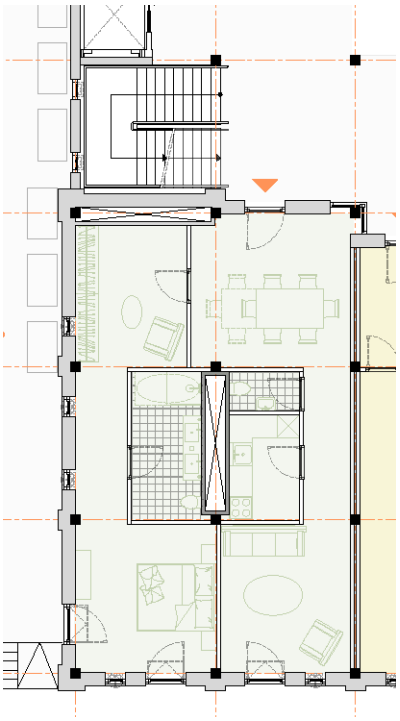


figure 3.53.

synthesis of results within a d

In most households, it is also very important to ventilate the home, both mechanically and naturally. Therefore, all households span over the entire depth of the individual buildings, allowing all households to aerate the house by opening a window on both sides of the house. In some cultures, like India, Indonesia, or China, traditional food has a stronger smell than in others, meaning that having a kitchen, which either borders the outside or is closed and has mechanical ventilation, is a must. When talking about climate comfort, each culture (and therefore household) has a different temperature at which they are comfortable. Therefore, making sure that the building has passive elements, like overhangs (on the roof and in the windows) on the south-facing façade, trees with grand foliage in the inner courtyard, or a ventilated façade system, allows the building to be very much self-regulated in warmer periods. In colder periods, the use of underfloor heating allows the maximum heating temperature to be limited due to the system's capacity.

When focussing on the smallest scale of the building, materialisation, texture and detailing play a big role in the use of the building. By using wood on the façades facing the inner courtyard, a lighter and warmer atmosphere is created as opposed to the darker ceramic tiles on the outer façade (see figures 3.44 & 3.52.). By making the railings of the gallery open and rounded, it is possible for residents to see each other through the railing and to personalise the railing in front of their house. In addition, to make the adaptation of interior walls more sustainable, the material used is hempcrete and the full interior of the houses is rendered with lime plaster. This allows for the interior walls to be easily demolished and reused almost 1:1 (IsoHemp, 2026).



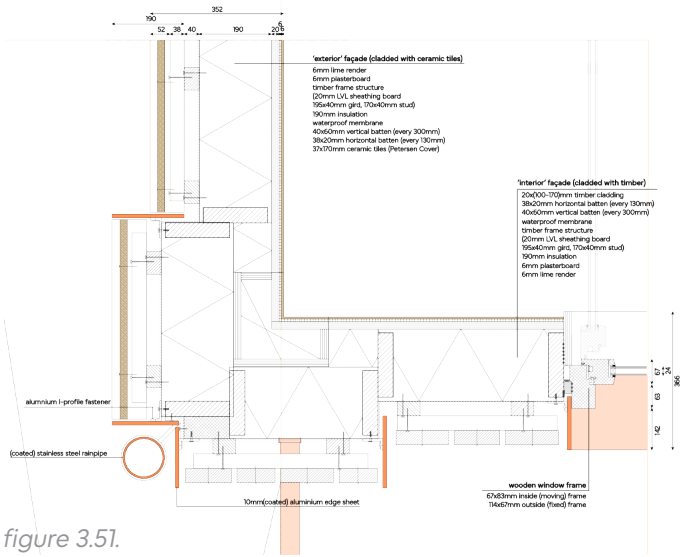


figure 3.51.



horizontal section b.

figure 3.52.

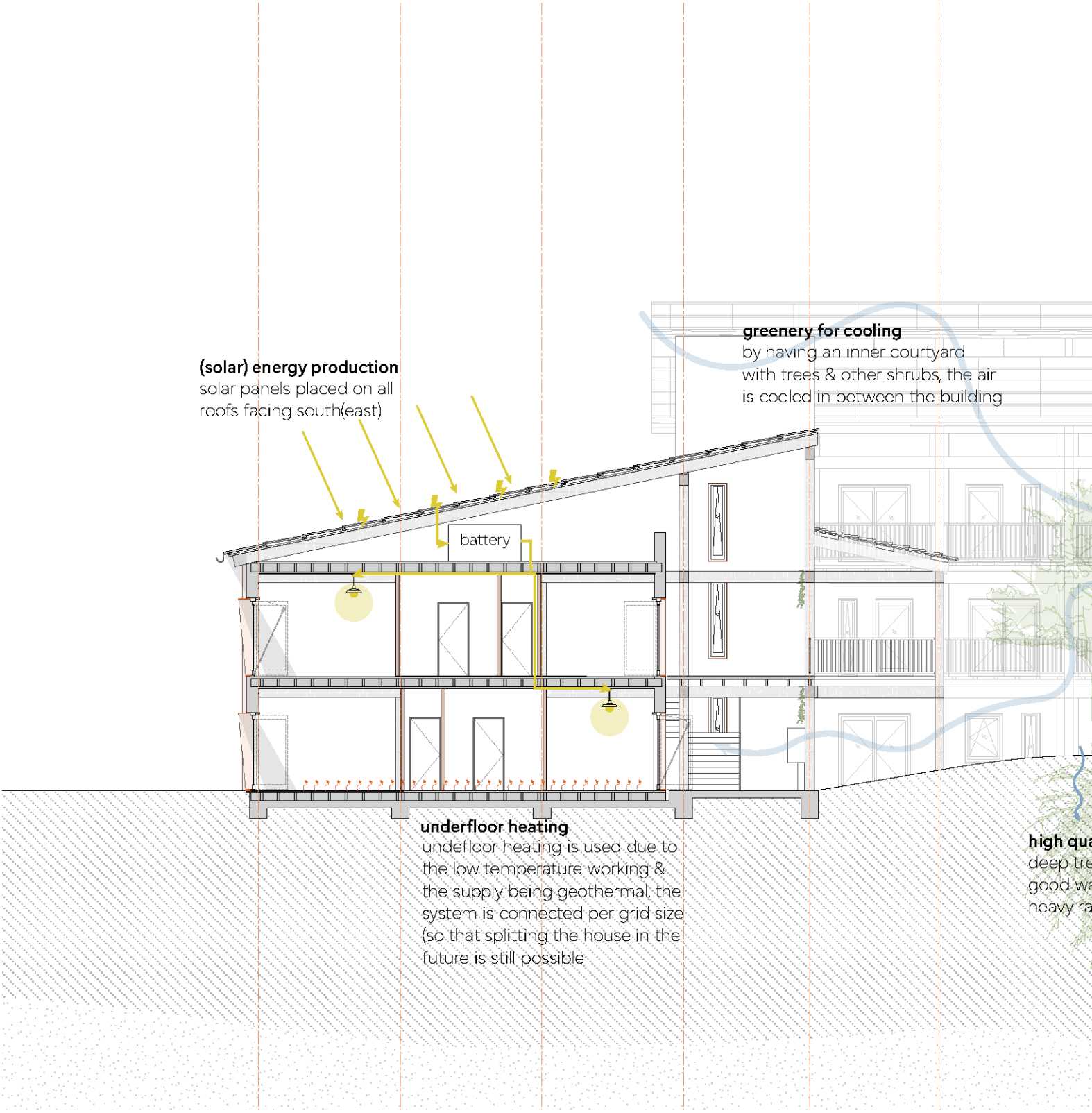


figure 3.50. *Elevation of wooden façade to show both the passive cooling (with the overhanging gallery) and the softer aesthetic as opposed to the other facade, scale 1.50 (scaled to 1.150. Author's work.*
figure 3.51. *Corner detail, where building goes from the ceramic tiles to the wooden cladding, scale 1.5 (scaled to 1.20). Author's work.*

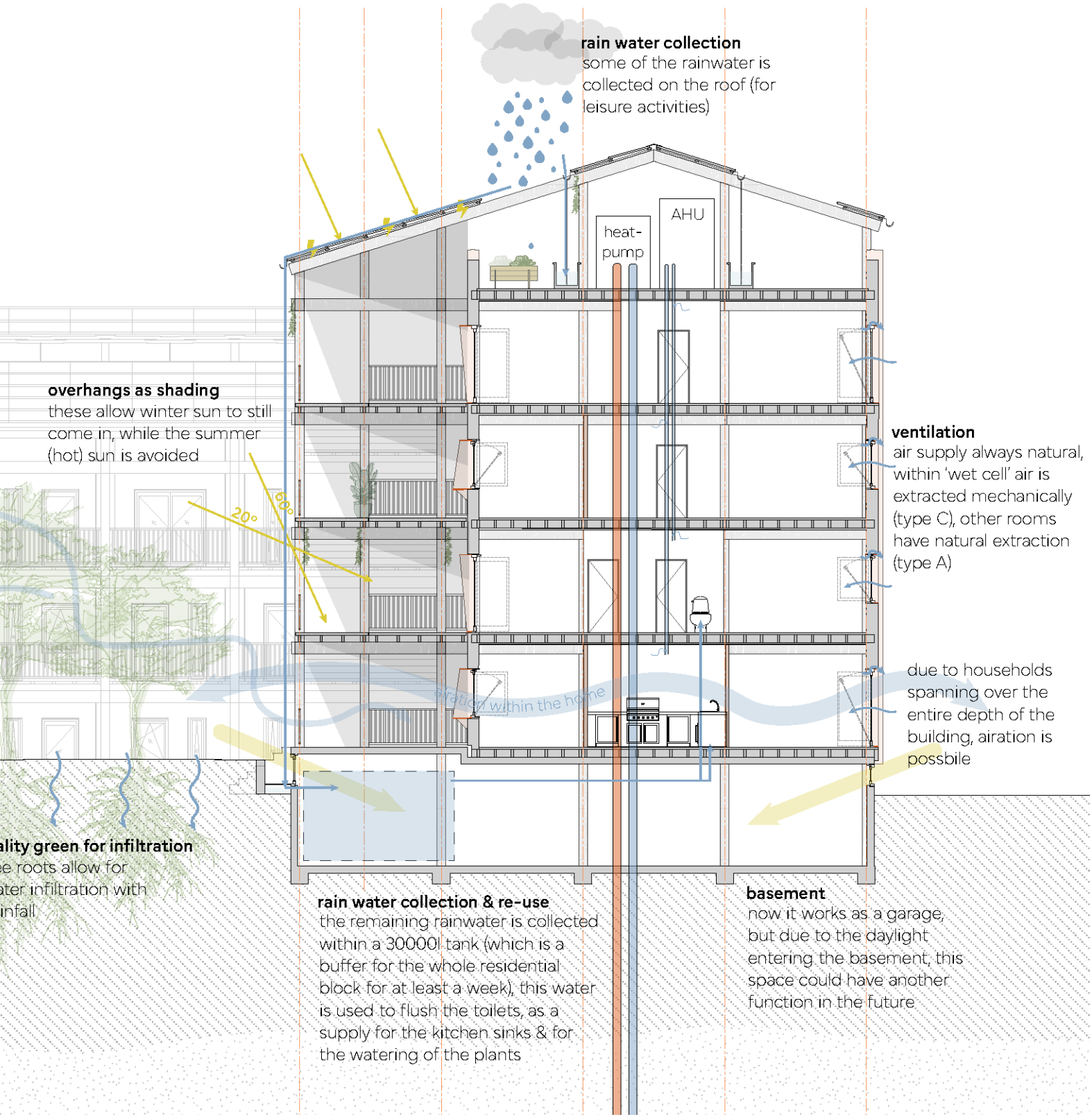


figure 3.53.

figure 3.52. *Façade fragment, of the exterior, mimicking the surrounding architecture while re-interpreting it in a modern way. This specific fragment is also on the north, meaning there was no real need for solar panels (on the roof) or big window overhangs, scale 1.50 (scaled to 1.150). Author's work.*

figure 3.53. *Climate section, depicting all climate related aspects that have been implemented within the design, scale 1.150. Author's work.*

4

conclusion.

After having developed the previously described design proposal, the question that remains is whether it is a representative example of an adaptive housing (building) system that accommodates changing needs and incorporates co-living principles.

conclusion.

Having integrated and compared different design principles through prototyping, the research proposes a synthesised design (see Appendix F for the full drawing set). Within a structural grid system of 3.7x4.05m, and a floor height of 3.3m, the design accommodates 10 different households (presented through the earlier-mentioned personas & colours).

After having developed the previously described design proposal, the question that remains is whether it is a representative example of an adaptive housing (building) system that accommodates changing needs and incorporates co-living principles.

If we go back to what we defined as an adaptive building system, we see that both Habraken's and Brand's theories clearly come back. The design uses a grid system, as is proposed in the 'open building' principles, that is repeated throughout the plot (3.7x4.05m). The building has a service shaft in the middle of the building volume and on alternating grid lines. This avoids ventilation, water, electricity & drainage systems from having to go through the entire home, which allows easier space plan adaptations (as those described for households E). To make sure the architecture invites residents to adapt the building (Schmidt III et al., 2010; Hertzberger, 1991), the column structure is placed so that it is partially visible on the inside and so that it causes an offset on the outside (see Figure 4.1). Additionally, the interior walls are made of hempcrete (rendered with lime), which allows for the walls to be broken down while the material can still be reused. Altogether, the system does clearly facilitate 'easy' adaptation, but this adaptation is mainly limited to a single household, unless several neighbours move out simultaneously.

Even though it is not possible to move around walls endlessly, the presence of 10 different households under one roof and within the same structure does show the design's versatility. By making sure there are slightly different design elements all through the residential block, like the orientation/positioning of the house within the block or the type of outside space the house borders or the available (shared) facilities, the design does indeed accommodate different needs. Due to the nature of this site (the 'bloemkoolwijk' within the city; Bron et al., 2021), the design does still require one to travel for, for example, groceries, work or school. The private bike & car park try to decrease that inconvenience. Adding the cultural layer to the user's spatial needs allowed the space plan of the households to be even more diverse (and therefore showed an ever wider possibility within the design). This layer also grounded the design better within its context, especially regarding future (ASML) developments within Eindhoven.

But how does everyone come together? Where do the 'casual interactions' occur? And what co-living principles can we identify? These are the questions that required a behavioural shift, which can only be done through small implementations. The circulation space (as suggested by Vestbro, 2010 and as concluded with studies in Appendix C) is placed like a gallery, around the building, bordering the homes and linked through lift & stair shafts. This space further stimulates interactions through the additional buffer space in between the houses and the walkway that serves as 'balconies' for some of the houses. In addition, by not adding laundry spaces to the individual houses, but only to the building as a whole (on the ground floor, and on the roof), residents are 'forced' to interact with one another when performing this daily task. To make these encounters memorable and worthy, at these same locations, there's either a cafe, a shared living/dining room (with a kitchen) or a rooftop lounge space, kitchenette or picnic table.

Through the design's site choice (the 'bloemkoolwijk') and the architectural elements reinterpreted from this typology, the design doesn't just densify this neighbourhood or allow for adaptability within itself, but also answers the question of adaptability of that housing typology. It incorporates the co-living principles that were already present in that context (through the courtyards and the shared outside space), while adding value to that same context through the addition of facilities and the diversification of that context.



figure 4.1. *Section model (scale 1.50), that represents the ideation of the project. Author's work.*

figure 4.1.

discussion.

While the research started with an open vision towards co-living, through analysis of co-living case studies and theoretical research, it became evident that many of the 'better' co-living designs require a bottom-up approach, something that was not possible within the scope of this research. Other case study analyses have shown that the act of 'co-living' is something that is mainly done by younger residents as opposed to the elderly (Martinez et al., 2020; Uyttebrouck & Teller, 2023; Jeske et al., 2024). This is mainly due to younger adults not having the money to afford more than a room, but also because the elderly value their personal space. Therefore, for future research, it is recommended that these factors be taken into account when designing for a co-living situation. It is also important to have a clear definition of what degree of co-living is wanted within the design, since the willingness of people sharing often depends a lot on their personal situation and therefore doesn't always support every household's needs.

When it comes to adaptability, the question of ownership plays a very important role. Whether people own their house individually, in a Collective Private Commissioning (CPC), or a housing corporation owns it, defines the reason and ease of adaptability within the building as a whole. For example, in the case of individual owners, it is much harder to change a household dividing wall than when a corporation owns the building and renters move in and out all the time. Therefore, investigating 'group' ownership, through structures like a CPC or PayItForward (TBI, 2021), of an adaptive residential block is much more interesting than when the building is owned by individuals.

reflection.

Due to the undertaken 'research-by-design' methodology, the entirety of the research has been a series of iterations where each iteration has informed the next, and moving back and forth between investigation, exploration and design has led to the results we see at the end.

Initially, defining a point of interest within the broader problem of the 'housing crisis' was quite challenging. Sub-problems were analysed, along with their related pains, and by doing this, certain trends seemed to be growing more rapidly than others. The correlation between single-person households and the elderly was most shocking, and the lack of proposed solutions or plans for this issue made it even more urgent. This gave the project a focus: why do elderly live on so many m^2, and how can we make sure that the m^2 per person is spread more equally.

From here, the research developed further. To specifically target the lowering of the m^2 per person, one of the solutions seemed to be co-living (Jeske et al., 2024). The more people you live with, the more rooms (& facilities) you can share. On the other hand, the decreasing size of newly built houses seemed to rapidly become an issue as well, due to the limitations of adaptation. Therefore, designing new housing with a more adaptive character would also help the elderly, and others, to make changes to their home when they no longer all that space.

By analysing and exploring through both a technical lens and the use(r) lens, the link between the physical architecture and its use is defined very explicitly. The analysis of case studies alongside theoretical frameworks made sure that design principles (or even rules) were grounded in existing buildings, as opposed to the speculative realm. Nonetheless, throughout the exploration and prototyping phase, it was sometimes very hard to make sure these two lenses merged. Especially after A1 & A2 assignments, taking a step back and understanding the relation between both the adaptiveness and the co-living principles allowed design choices to be much better argued than they were before.

This research hopes to not only add to the architectural design possibilities, but also to the importance of user research and how this is not just a demographic analysis but also one of culture, values and perceptions. Taking into account the cultural research related to housing and its residents allows architectural designs to go beyond the physical realm and affect behavioural changes while also affecting the associated emotions people have with their home. At the end of the day, we all desire a home that we can grow old (in).



5

bibliography.

per section.

introduction.

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appendices.

All additional research & drawings can be found within the appendices.

Appendix A - Defined Personas
Appendix B - Open Building Studies
Appendix C - Co-Living Studies
Appendix D - Integrated Prototypes
Appendix E - Initial (A2) Design Exploration
Appendix F - Final Design Proposal (drawing set)
Appendix G - Demographic Mapping of Eindhoven

appendix a.

This appendix has been collected into a booklet. The booklet itself describes detailed literature research regarding residents' spatial needs and develops these into personas and their associeated households. These personas are used as a red thread throughout the entirity of the project. At the end of the booklet, a series of design proposals have been made that show these houdeholds in a floorplan and how these are related to the rules.



household studies.

an analysis of **people's spatial needs.**

april 2026

emma.
van barneveld.

tu delft
master thesis.

table of contents.

introduction. [4-7]

people in eindhoven.

spatial needs defined by rules.

ten personas. [8-17]

martha, elise & daniëlle.

haitao.

anaya.

julie & anna.

arjun & diya, with their new-born.

kadir & elif, with their two children.

ibrahim & anisa, with their three children & anisa's parents.

henk & patrizia.

piet & henriet.

erita.

the personas & their houses. [18-28]

bibliography. [29]

introduction.

people in eindhoven.

For this research, the scope has been limited to Eindhoven, as a case in which this new form of dwelling can take place. To make sure it fits within this context, it is important to understand what type of people we can find here.

All through Eindhoven, there's been a cultural diversification in the population. We can see this in figure 1.0, which means there's an increasing diversification in the ways of living. This is a change which can also be seen within Limbeek (the area in which we can find the chosen design location). Therefore, when looking into the households within Eindhoven and what their spatial needs are, it is impossible to ignore people's cultural background. Designing adaptive dwellings for the changing residents doesn't become simply a matter of age-related needs, but also one of cultural needs.

If we zoom in even further, into what specific countries people in Eindhoven are actually from, we find a very long list (see figure 1.2). For this research, a focus has been put on all those cultures that are represented with over 1,5% in Eindhoven so that the research can be done in depth for these cultures. Combining these cultures & the different age groups present within the design area leads to ten personas:

figure 1.0. *Cultural diversification of the population in Eindhoven. Author's work based on Basisregistratie personen (2025).*
figure 1.1. *Cultural diversification of the population in the area of Limbeek. Author's work based on AlleCijfers (2026).*
figure 1.2. *List of countries where the population of Eindhoven originates from. Author's work based on AlleCijfers (2026).*
figure 1.3. *Age of residents in the area of Limbeek. Author's work based on AlleCijfers (2026).*

1. **Martha, Elise & Daniëlle**, three Dutch students/ starters sharing a house
2. **Haitao**, a Chinese starter who moved to the Netherlands for his studies and has decided to stay there for work
3. **Anaya**, an Indian student who moved to Eindhoven for her studies
4. **Julie & Anna**, a Dutch and Polish couple in their early 30s, living their best YUP life
5. **Arjun & Diya**, an Indian couple in their 30s, who moved to the Netherlands to work for ASML who have just had a child
6. **Kadir & Alif**, form a Turkish (small) family with two children at home; Alif's mum cannot fully care for herself, so she lives in the apartment next door
7. **Ibrahim & Anisa**, form a big Moroccan family with three children at home & one older son (Nabil) who's left the house (who were all born in the Netherlands); Anisa's parents also live with them
8. **Henk & Patrizia**, are recent empty nesters (from the Netherlands & Germany)
9. **Piet & Henriet**, a Dutch couple who have lived in Eindhoven their whole life and who's family live in and around Eindhoven
10. **Erita**, a single Indonesian elderly widow, with some family in Eindhoven, but most have left

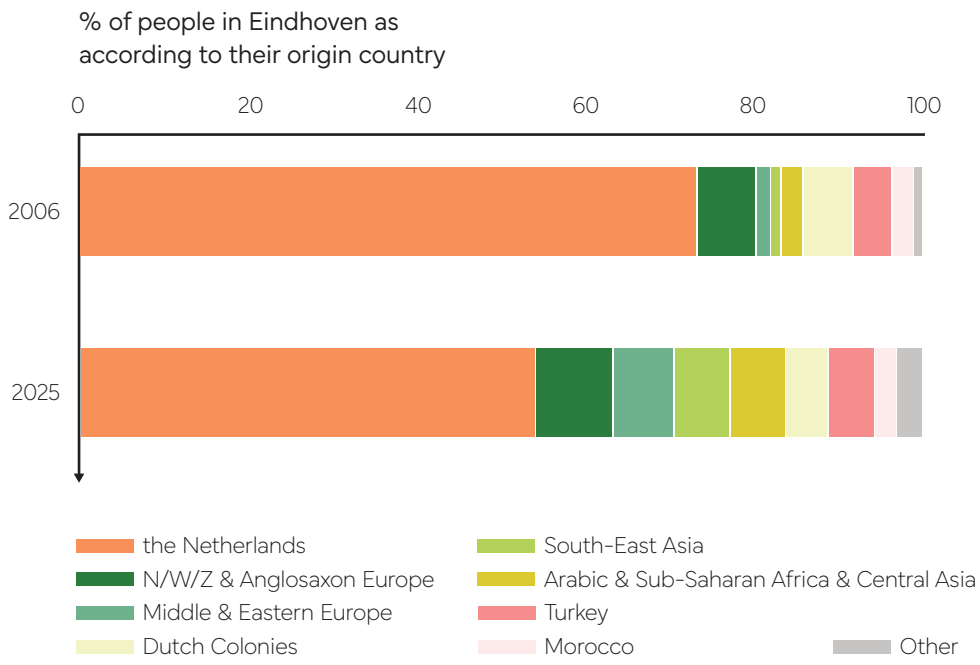


figure 1.0.

Country of origin	Total People	Percentage
Netherlands	134959	54.20%
Turkey	13581	5.45%
India	9214	3.70%
Morocco	6975	2.80%
Indonesia	5631	2.26%
Poland	4956	1.99%
Germany	4682	1.88%
China	4167	1.67%
Suriname	3731	1.50%
Syria	3293	1.32%
Belgium	2760	1.11%
Curacao	2416	0.97%
Spain	2309	0.93%
Rumania	2098	0.84%
Bulgaria	2061	0.83%
Ukraine	2004	0.80%
Italy	1935	0.78%
Iran	1882	0.76%
Brazil	1746	0.70%
UK	1714	0.69%
Portugal	1605	0.64%
Somalia	1469	0.59%
Greece	1359	0.55%
Russia	1241	0.50%
Afghanistan	1231	0.49%
France	1225	0.49%
USA	1196	0.48%
Irak	1160	0.47%
South Africa	1110	0.45%
Egypt	1070	0.43%
Hungary	909	0.37%
Vietnam	770	0.31%
Bosnia Herzegovina	686	0.28%
Aruba	618	0.25%
Ethiopia	616	0.25%
Thailand	590	0.24%
Philippines	573	0.23%
Serbia	528	0.21%
Eritrea	512	0.21%
Colombia	499	0.20%
Pakistan	489	0.20%
Nigeria	479	0.19%
Australia	388	0.16%
Ghana	370	0.15%
Canada	367	0.15%
Cape Verde	26	0.01%
Unknown	15787	6.34%
	248987	

figure 1.2.

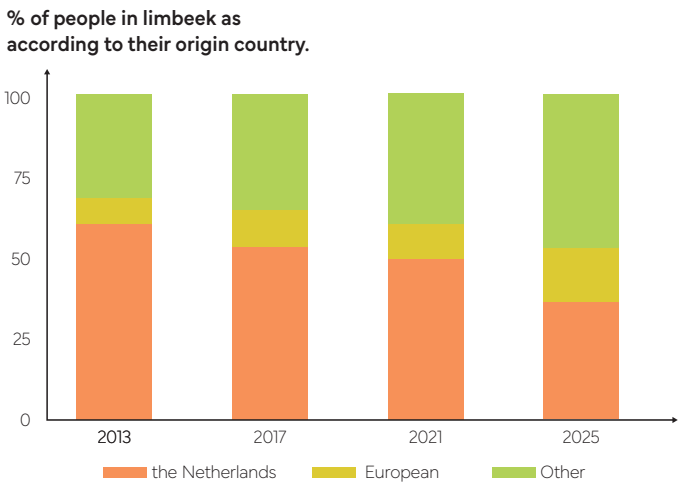


figure 1.1.

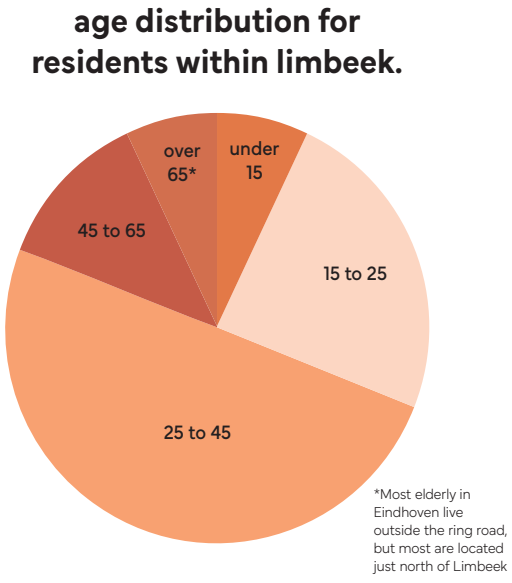


figure 1.3.

introduction (cont.).

spatial needs defined by rules.

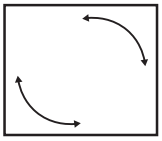
Each persona described previously belongs to a certain household. So, in order to identify what the spatial needs fo these people are, an in-depth research was done of these cultures (diving into analyses of case-studies of traditional & recent dwellings within these cultures) & these ages (diving into the BPD personas present within the Netherlands). From this research, several rules were developed to make design choices easier. These are defined in diagrams below.

The needs per persona are defined in the following pages & drawn in a schematic floor plan of connecting spaces. Later, these needs are translated into a floor plan within the design proposal & the rules suggested on the right are identified within this floor plan.

rules based on age-related spatial needs.

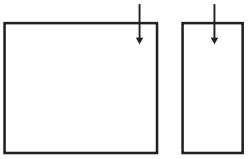
Rule 1 – the toilet & bathroom

(young) single person



in same space

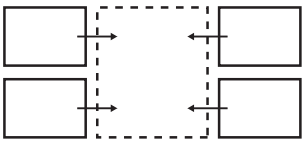
couples, shared housing, families & elderly



seperate

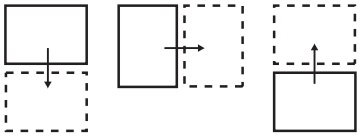
Rule 2 – outside space

young singles & couples



shared

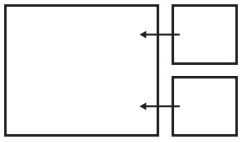
families & older couples/singles



private

Rule 3 – presence of a home office

young couples & small families



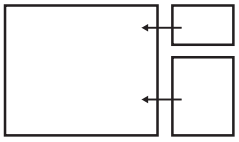
office (or baby room) seperate from bedroom

young singles & bigger families



office in the bedroom

elderly

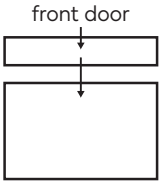


no office, but guest bedroom

rules based on cultural spatial needs.

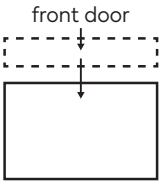
Rule 1 – the front door/entrace space

moroccan



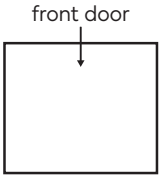
indoor buffer

chinese



transition in- to outside

all other cultures



no need for buffer

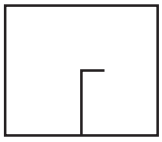
Rule 2 – the kitchen

dutch, german & polish



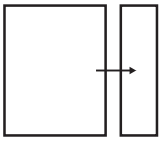
open

indian & moroccan



semi-open

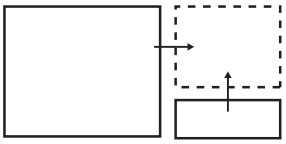
turkish, chinese & indonesian



seperate

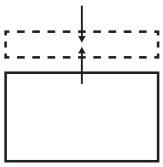
Rule 3 – outside space

indian, turkish, indonesian, dutch, german & polish



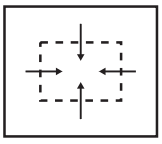
connected to kitchen and/or living (& dining) room

chinese



as a transition space

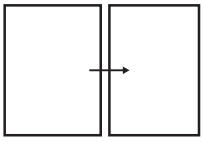
moroccan



enclosed by house

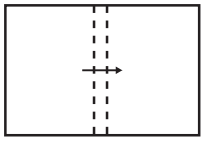
Rule 4 – bedroom

turkish, indonesian & chinese



seperate (privacy is important)

moroccan, indian, dutch, german & polish



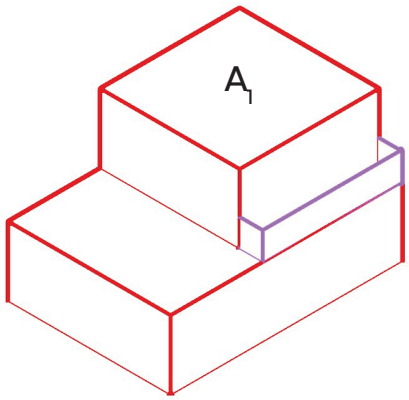
preferably seperate, but studio is accepted when living alone

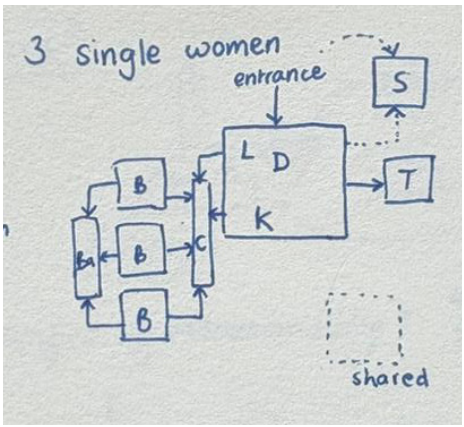
martha, elise & daniëlle.

3 single (women) young professionals.



maximum m²	100 m²
(bed)rooms	3 bedrooms of equal size min 3x3m, 9m²
kitchen	open kitchen plan
outside space	terrace or balcony, but can be shared
extra spaces?	storage space is nice due to small bedrooms
special home arragements	big open living room, to also invite guest for dinner or parties, seperate toilet from bathroom

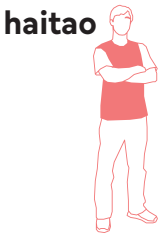


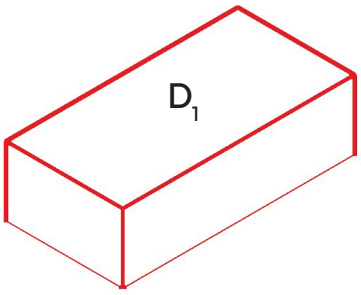


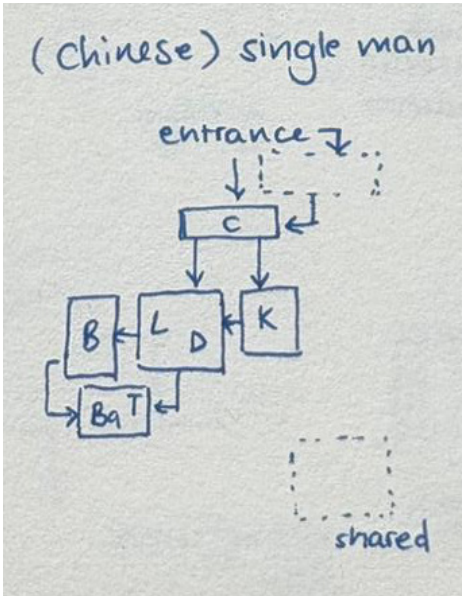
haitao.

young (chinese) single man.

maximum m²	60 m²
(bed)rooms	min. 2 rooms, bedroom and living/dining room
kitchen	kitchen in a seperate room
outside space	veranda space or courtyard is preferred, can be shared
extra spaces?	veranda space, edge between in- and outside, potentially a guest room (can be outside own house)
special home arragements	people can't walk straight into the bedroom or living room, there must be a buffer zone (also for shoes)







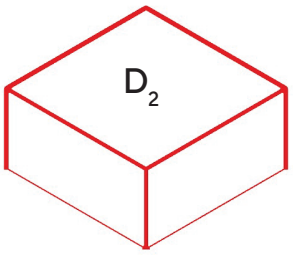
anaya.

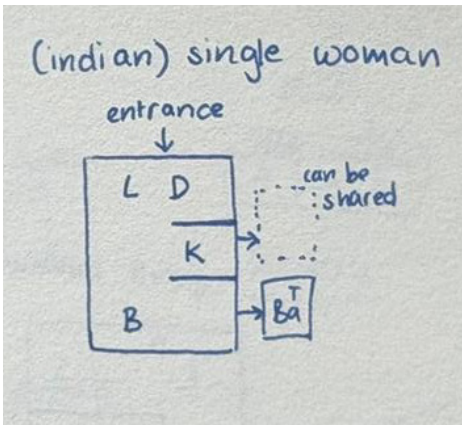
young (indian) single woman.

maximum m²	35 m²
(bed)rooms	studio room
kitchen	kitchen has an open wall to dining space
outside space	attached to kitchen, can be shared
extra spaces?	guest room for family visiting, a shared office space or a neighbours meeting space
special home arragements	outside space attached to kitchen



anaya



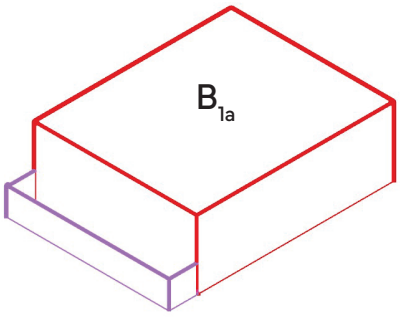


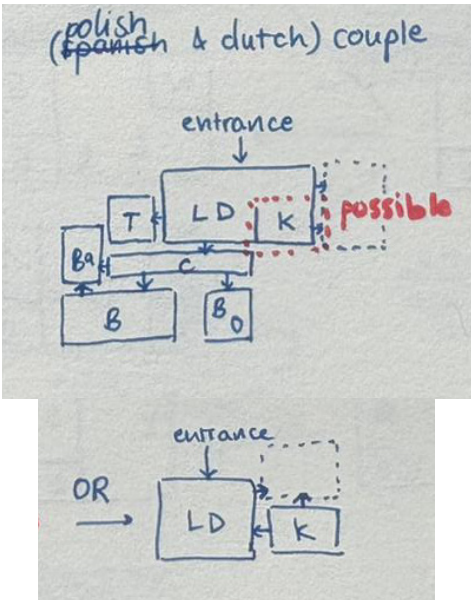
julie & anna.

young (dutch & polish) couple.

maximum m²	70 m²
(bed)rooms	2 bedrooms, 1 master one guest/home office
kitchen	kitchen is partially open, due to smells
outside space	terrace or balcony
extra spaces?	home office is preferred, but can also be the guest bedroom or future baby room
special home arragements	big windows, and kitchen must be able to air through



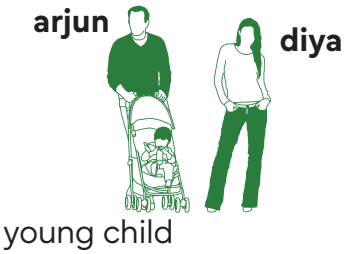




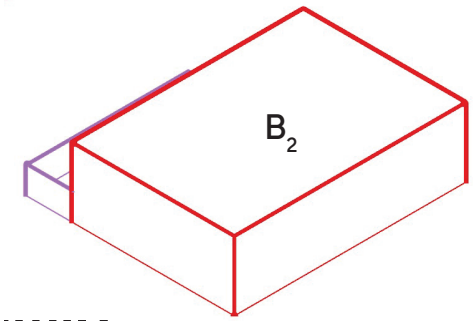
arjun & diya, with their new-born.

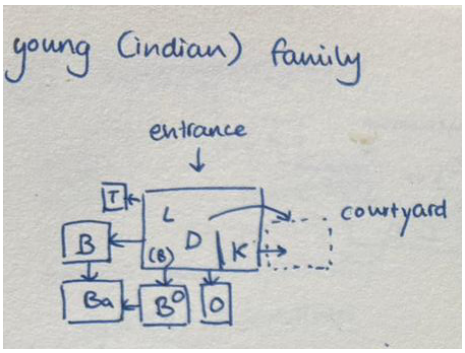
young (indian) family.

maximum m²	80 m²
(bed)rooms	min. 2 bedrooms, 1 master one baby/guest room
kitchen	kitchen in a seperate room
outside space	balcony or terrace, attached to kitchen or dining room
extra spaces?	home office is a must, a guest room for family is preferred can be outside of the house
special home arragements	outside space attached to kitchen, child daycare is preferred, inner courtyard connection



young child

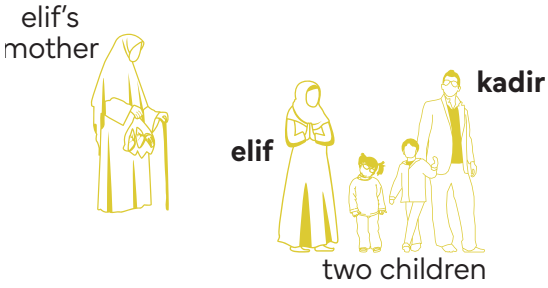


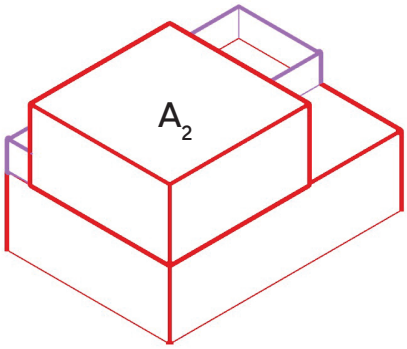


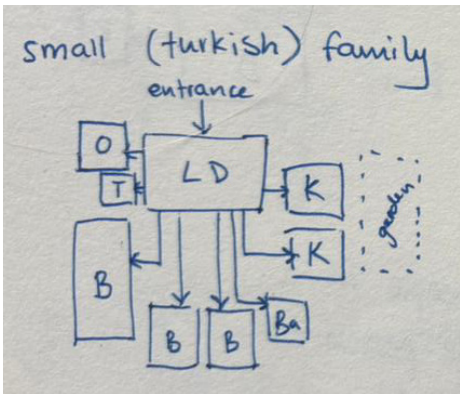
ibrahim & anisa, with their three children & anisa's parents.

small (turkish) family.

maximum m²	100 m²
(bed)rooms	3 bedrooms (1 master, 2 smaller)
kitchen	kitchen is closed & connected to outside
outside space	preferred to have a garden or an inner courtyard
extra spaces?	no need for a home office, might need space for family or grandparents in the future
special home arragements	two floors preferrably (downstairs is private and connected to a garden or courtyard, but has the kitchen, storage & guest space; upstairs has the living room and bedrooms)





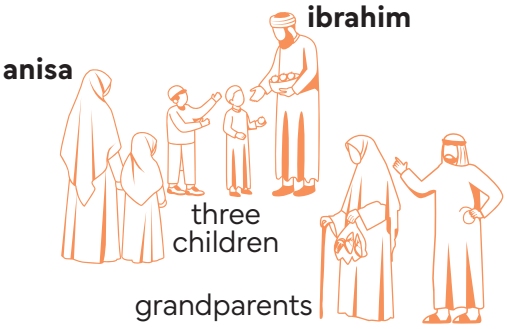


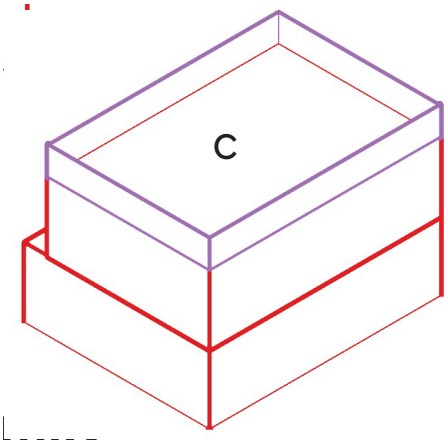
ibrahim & anisa, with their three children & anisa's parents.

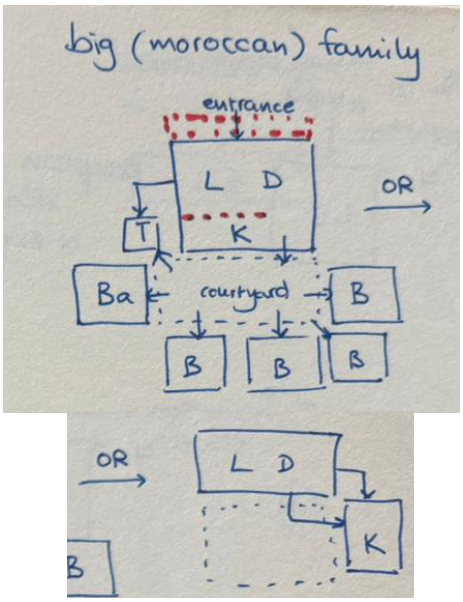
big (moroccan) family.

maximum m²	150 m²
(bed)rooms	5 bedrooms (2 master, 3 smaller)
kitchen	kitchen is open to dining room
outside space	private courtyard that encloses the rooms & terrace?
extra spaces?	preferrably one extra bedroom for guests, seperate living from dining room
special home arragements	more than one floor, and privacy on floors where public looks in (small windows or just walls), the inner part of the house is open and rooms are on the sides





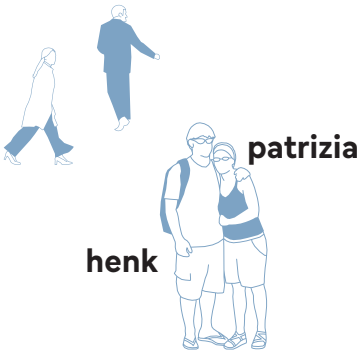


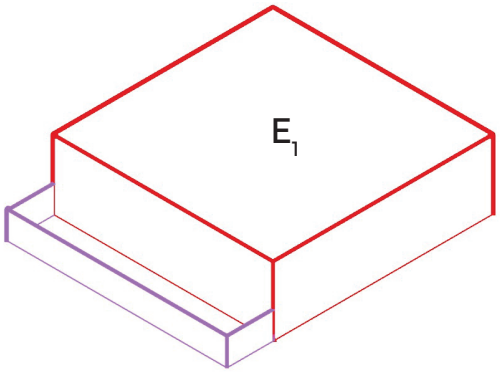


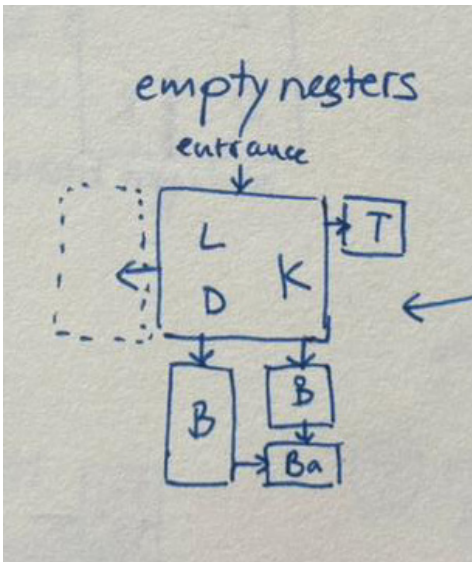
henk & patrizia.

(german & dutch) emptynesters.

maximum m²	90 m²
(bed)rooms	2 bedrooms (1 master with ensuite bathroom, 1 smaller)
kitchen	open kitchen plan
outside space	outside space oriented on the sun, balcony or garden
extra spaces?	seperate toilet, guest room in the house and maybe more outside the house
special home arragements	seperate toilet from bathroom, spacious living & dining room for (dinner) parties and family visiting





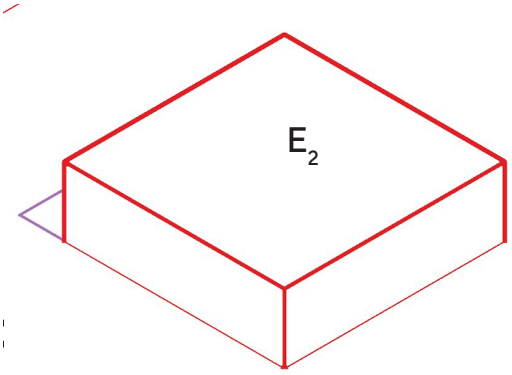


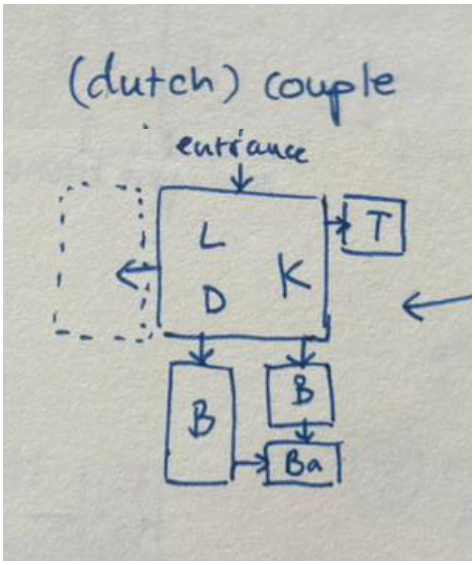
piet & henriët.

elderly (dutch) couple.

maximum m²	90 m²
(bed)rooms	2 bedrooms (1 master with ensuite bathroom, 1 smaller)
kitchen	open kitchen plan
outside space	outside garden, oriented on the sun is a nice-to-have
extra spaces?	seperate toilet, guest room in the house (and more outside), places for interaction with neighbours
special home arragements	seperate toilet from bathroom, spacious living & dining room for (dinner) parties and family visiting







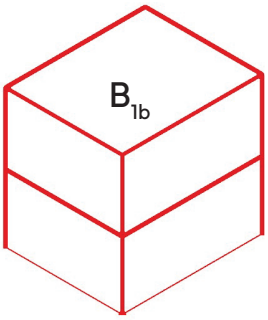
erita.

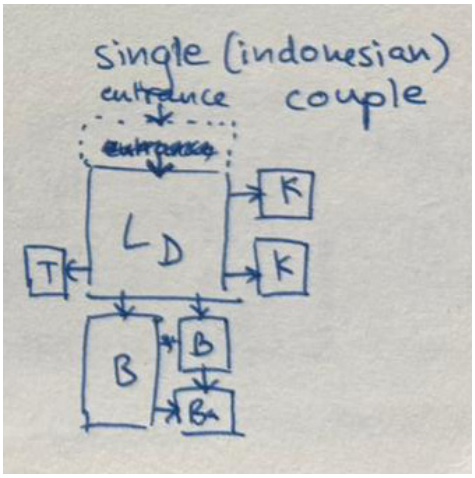
single (indonesian) elderly woman.

maximum m²	60 m²
(bed)rooms	1 bedroom with ensuite bathroom
kitchen	two separate kitchens, a wet for cleaning and a dry for storage & cooking
outside space	outside space, but shared is good for the connection
extra spaces?	a guest room, outside the house for family visiting, shared spaces to connect with neighbours
special home arragements	can be in two floors, but important part is to have a clear separation between the public (living, guest & kitchen space) and the private (bedroom & bathroom)



erita





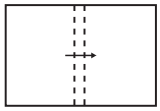
the personas & their houses.

3 single (women) young professionals.



bedrooms.
3 similar sized bedrooms

moroccan, indian, dutch, german & polish



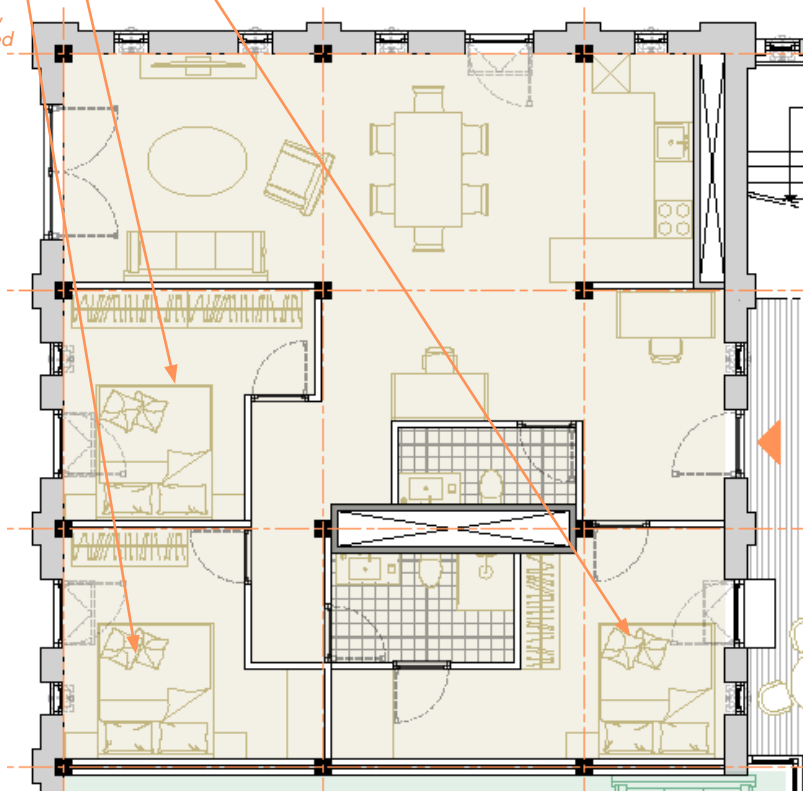
preferably seperate, but studio is accepted when living alone

kitchen.

dutch, german & polish



open



home office.

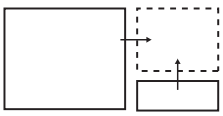
young singles & bigger families



office in the bedroom

outside space.

indian, turkish, indonesian, dutch, german & polish

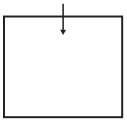


connected to kitchen and/or living (& dining) room

entrance.

all other cultures

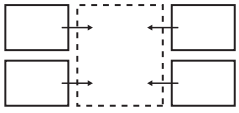
front door



no need for buffer

outside space.

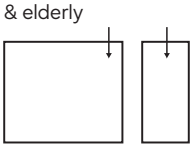
young singles & couples



shared

bathroom & toilet.

couples, shared housing, families & elderly



seperate

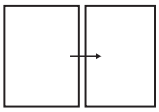
young (chinese) single man.

haitao

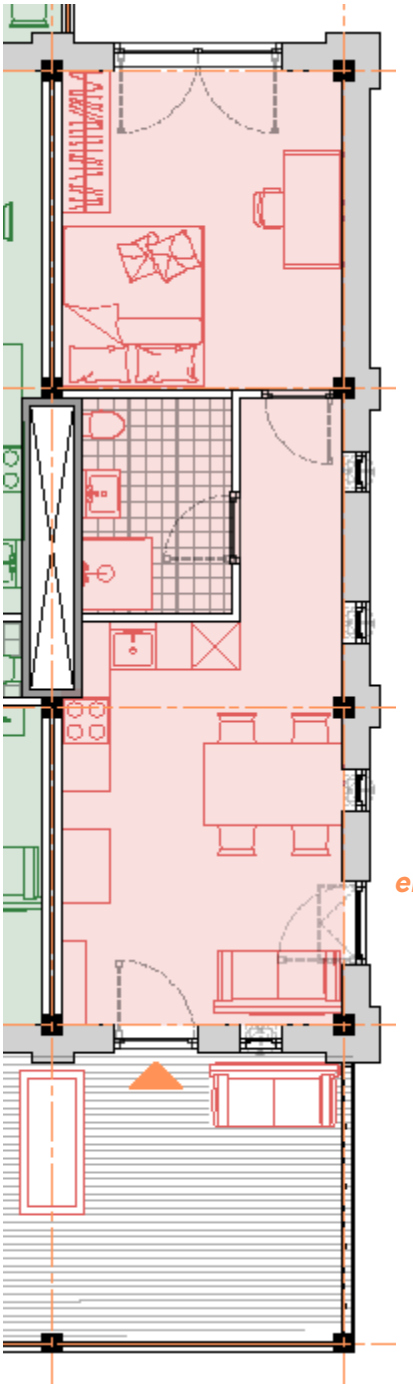


bedroom.

turkish, indonesian & chinese



seperate (privacy is important)



home office.

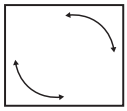
young singles & bigger families



office in the bedroom

bathroom & toilet.

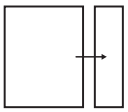
(young) single person



in same space

kitchen.

turkish, chinese & indonesian



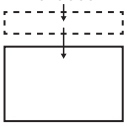
seperate

the home is too small for this

entrance.

chinese

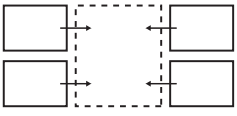
front door



transition in- to outside

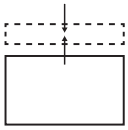
outside space.

young singles & couples



shared

chinese



as a transition space

the personas & their houses.

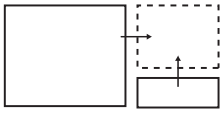
young (indian) single woman.



anaya

outside space.

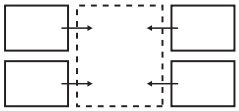
indian, turkish, indonesian, dutch, german & polish



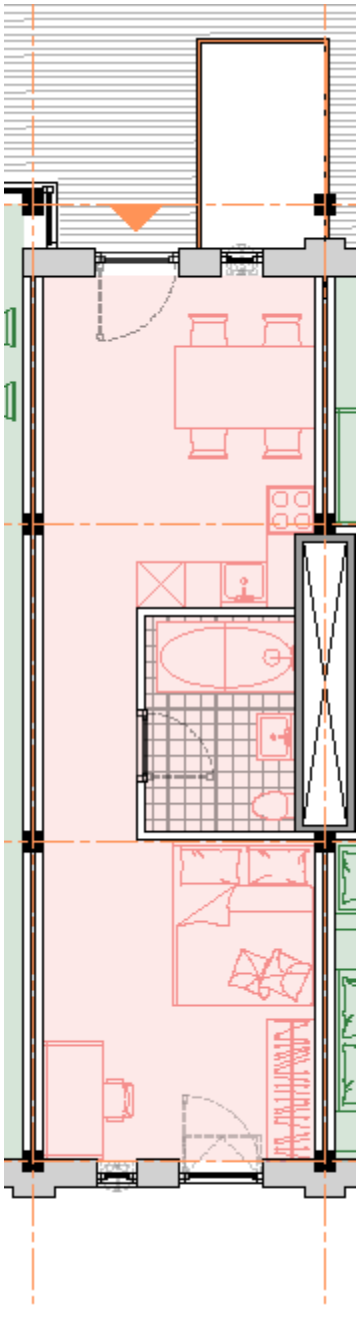
connected to kitchen and/or living (& dining) room

outside space.

young singles & couples



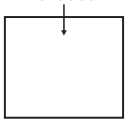
shared



entrance.

all other cultures

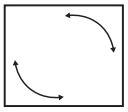
front door



no need for buffer

bathroom & toilet.

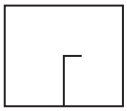
(young) single person



in same space

kitchen.

indian & moroccan



semi-open

home office.

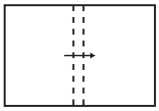
young singles & bigger families



office in the bedroom

bedroom.

moroccan, indian, dutch, german & polish



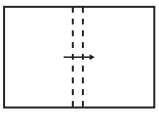
preferably seperate, but studio is accepted when living alone

young (dutch & polish) couple.



bedroom.

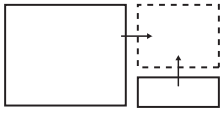
moroccan, indian, dutch, german & polish



preferably seperate, but studio is accepted when living alone

outside space.

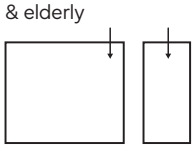
indian, turkish, indonesian, dutch, german & polish



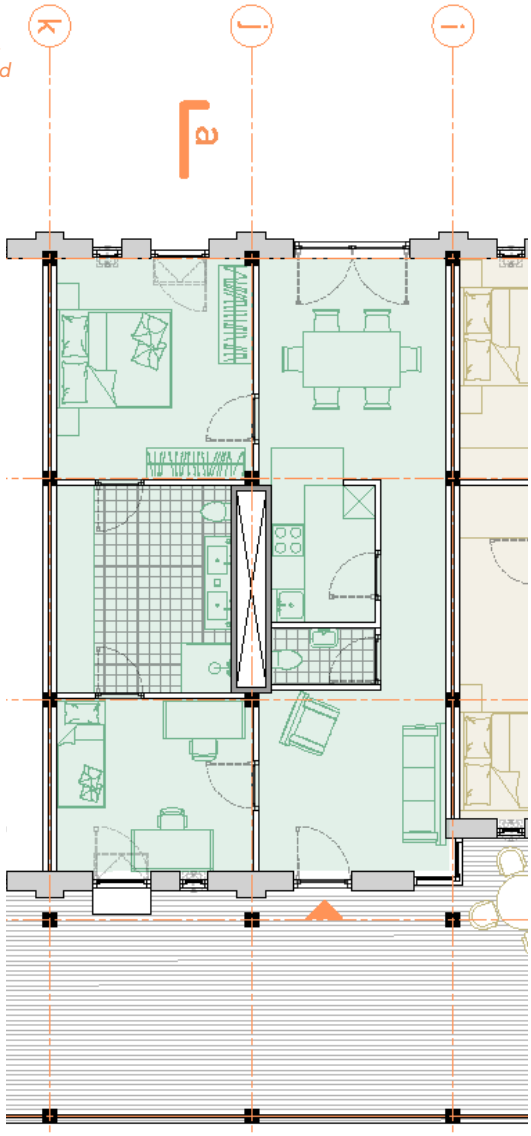
connected to kitchen and/or living (& dining) room

bathroom & toilet.

couples, shared housing, families & elderly



seperate



kitchen.

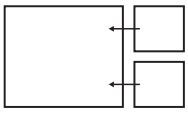
dutch, german & polish



open

home office.

young couples & small families

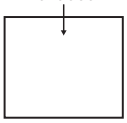


office (or baby room) seperate from bedroom

entrance.

all other cultures

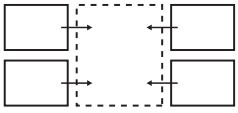
front door



no need for buffer

outside space.

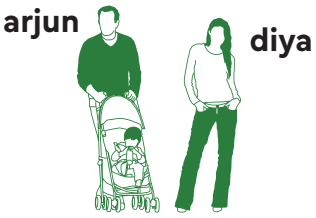
young singles & couples



shared

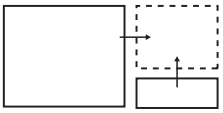
the personas & their houses.

young (indian) family.



outside space.

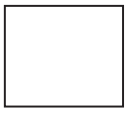
indian, turkish, indonesian, dutch, german & polish



connected to kitchen and/or living (& dining) room

home office.

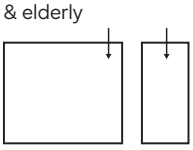
young singles & bigger families



office in the bedroom

bathroom & toilet.

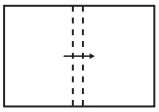
couples, shared housing, families & elderly



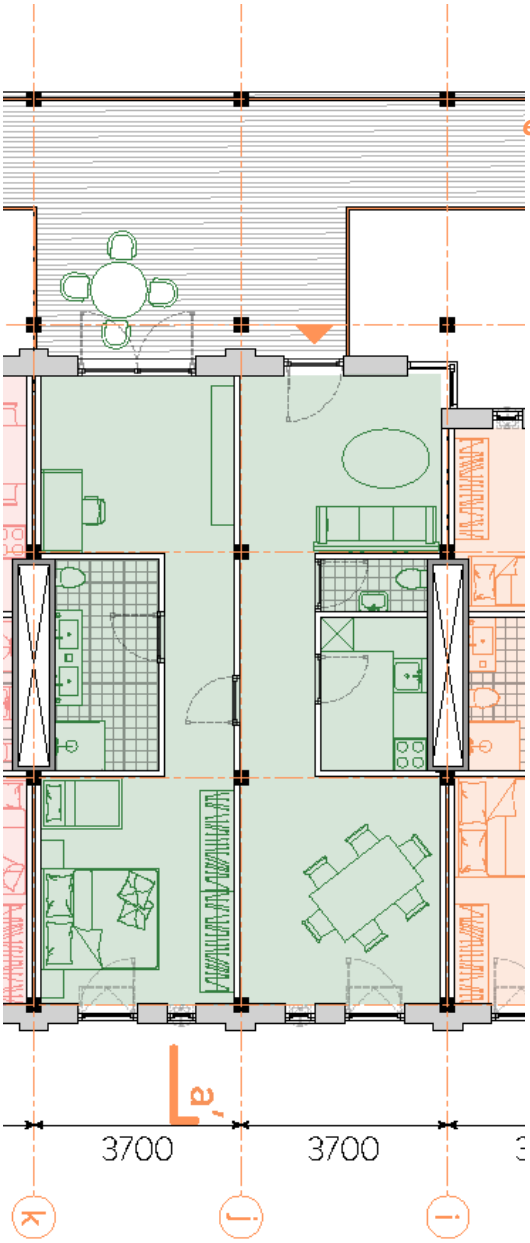
seperate

bedroom.

moroccan, indian, dutch, german & polish



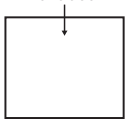
preferably seperate, but studio is accepted when living alone



entrance.

all other cultures

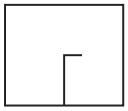
front door



no need for buffer

kitchen.

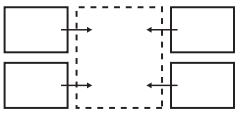
indian & moroccan



semi-open

outside space.

young singles & couples

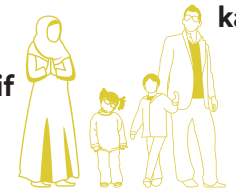


shared

small (turkish) family.

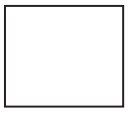
elif's mother





home office.

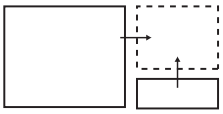
young singles & bigger families



office in the bedroom

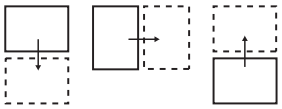
outside space.

indian, turkish, indonesian, dutch, german & polish



connected to kitchen and/or living (& dining) room

families & older couples/singles

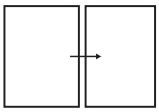


private

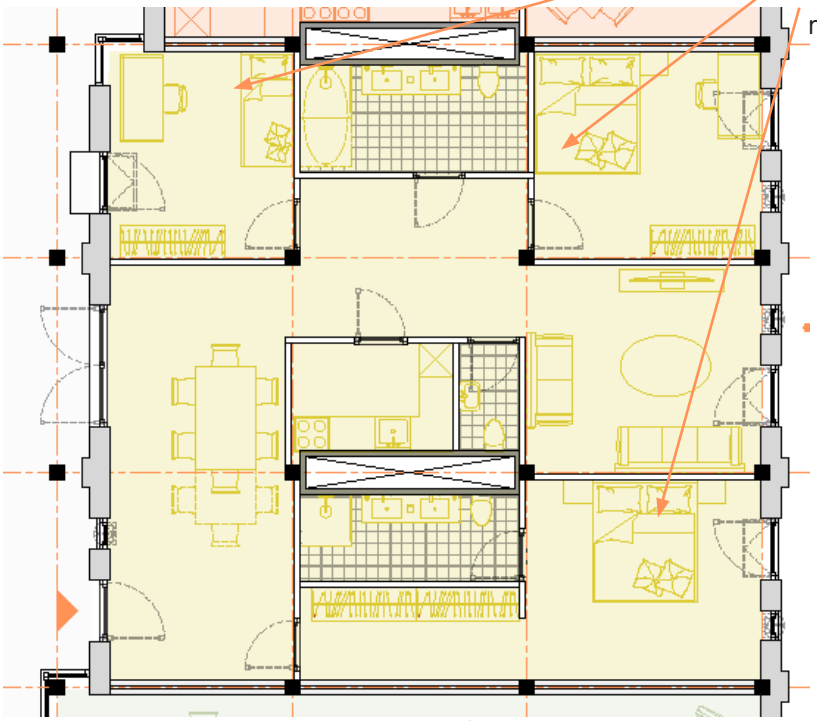
bedrooms.

at least 1 master bedroom (w/ ensuite bathroom)
2 children/grandparent room

turkish, indonesian & chinese

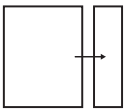


seperate (privacy is important)



kitchen.

turkish, chinese & indonesian

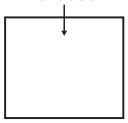


seperate

entrance.

all other cultures

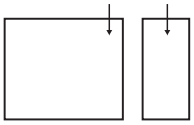
front door



no need for buffer

bathroom & toilet.

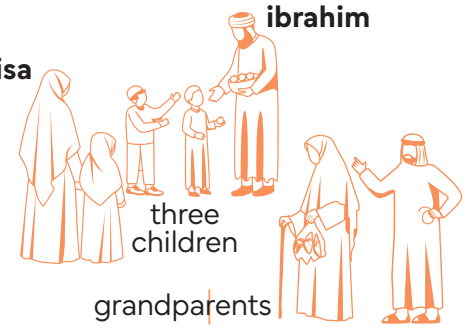
couples, shared housing, families & elderly



seperate

the personas & their houses.

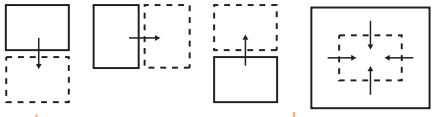
big (moroccan) family.



outside space.

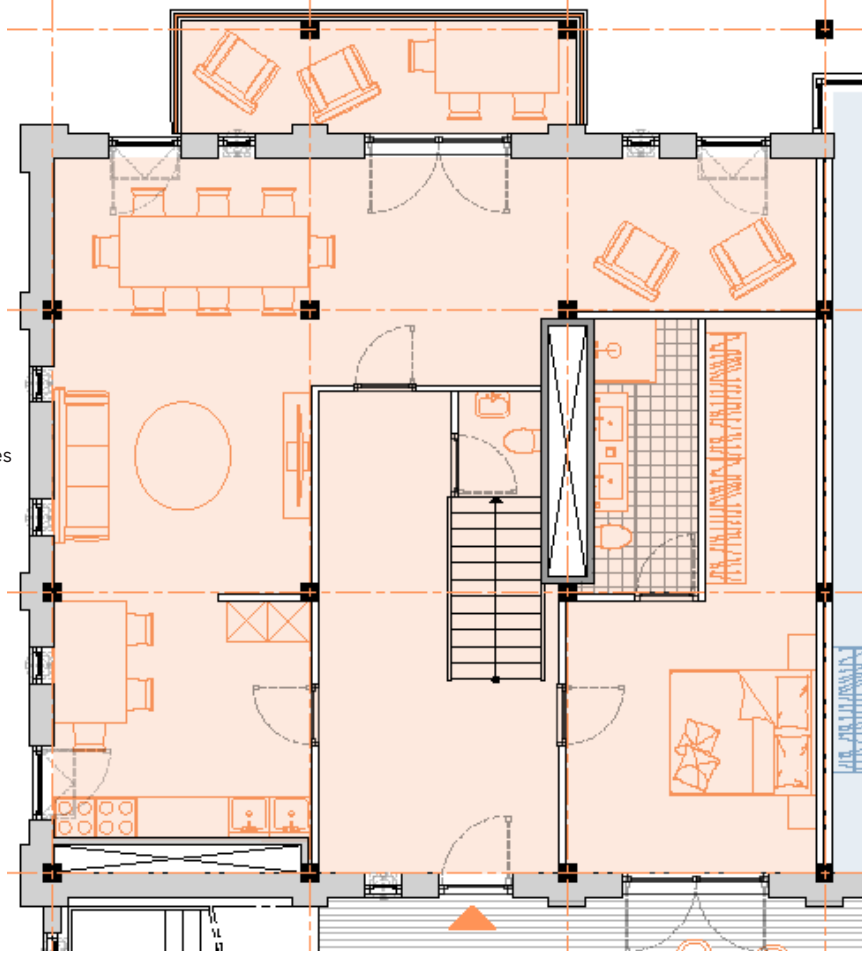
families & older couples/singles

moroccan



private

enclosed by house



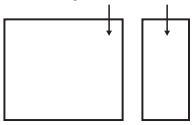
guest bedroom.
extra (shared) guest room for visiting friends & family

nabil
eldest son



bathroom & toilet.

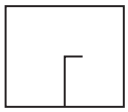
couples, shared housing, families & elderly



seperate

kitchen.

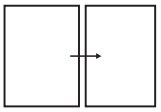
indian & moroccan



semi-open

bedrooms.
1 bedroom on the ground floor for the grandparents (w/ ensuite bathroom)

turkish, indonesian & chinese

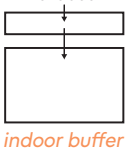


seperate (privacy is important)

entrance.

moroccan

front door

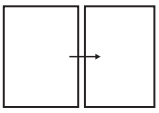


indoor buffer

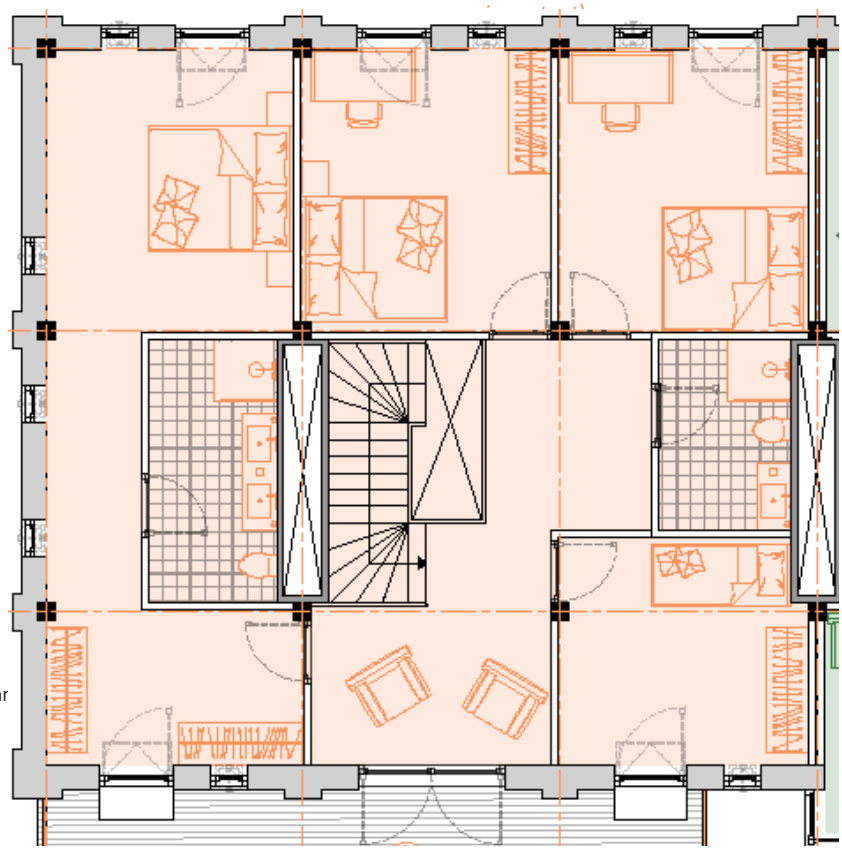
'ground' floor

bedrooms.
at least 1 master bedroom
(w/ ensuite bathroom)
2 bedrooms upstairs

turkish, indonesian
& chinese



seperate
(privacy is

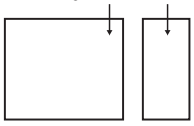


home office.
young singles &
bigger families



office in the
bedroom

bathroom & toilet.
couples, shared housing, far
& elderly



seperate

'first' floor

the personas & their houses.

(german & dutch) emptynesters.

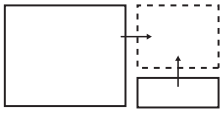


patrizia

henk

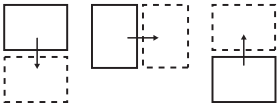
outside space.

indian, turkish, indonesian, dutch, german & polish

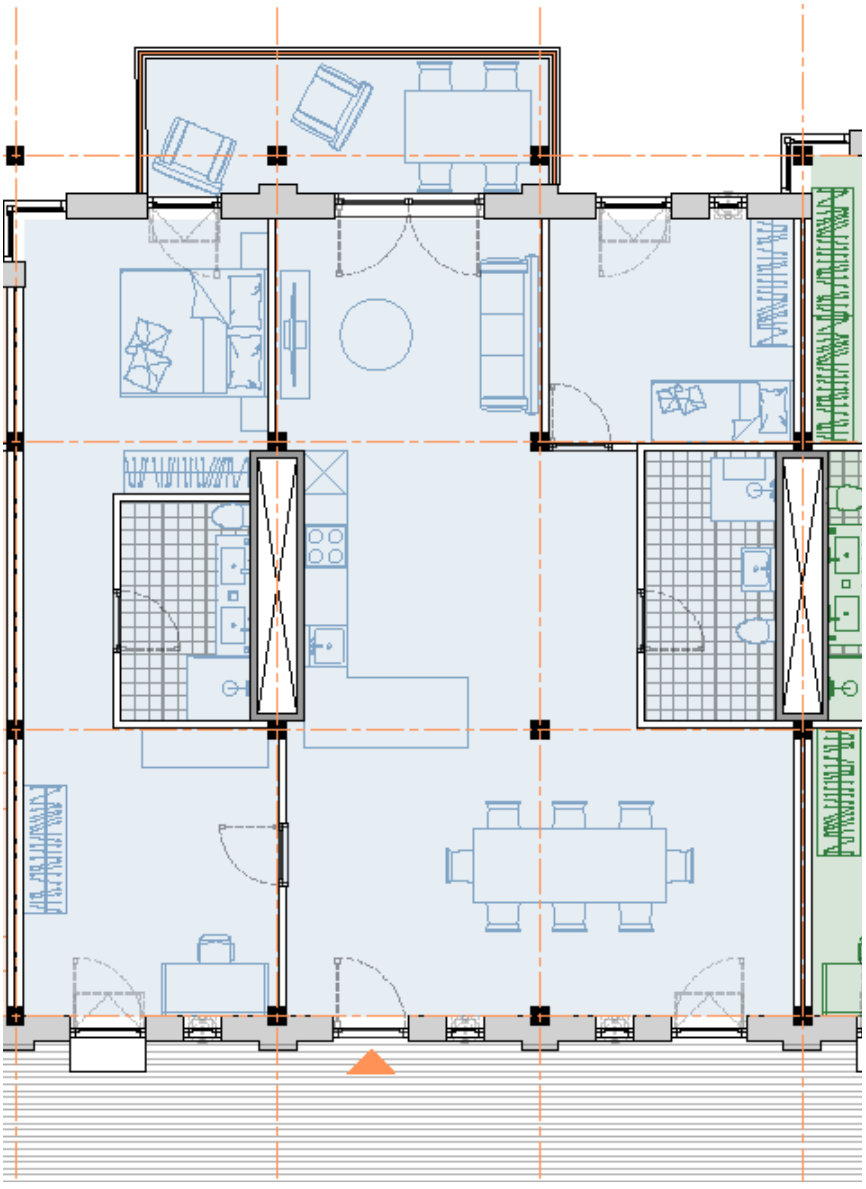


connected to kitchen and/or living (& dining) room

families & older couples/singles

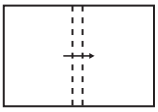


private



bedroom.

moroccan, indian, dutch, german & polish



preferably seperate, but studio is accepted when living alone

kitchen.

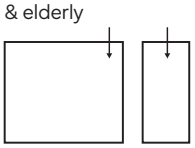
dutch, german & polish



open

bathroom & toilet.

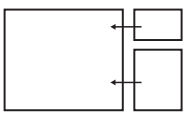
couples, shared housing, families & elderly



seperate

home office.

elderly

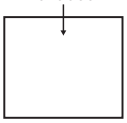


no office, but guest bedroom

entrance.

all other cultures

front door



no need for buffer

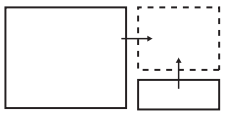
elderly (dutch) couple.

piet **henriët**



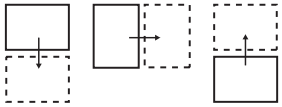
outside space.

indian, turkish, indonesian, dutch, german & polish

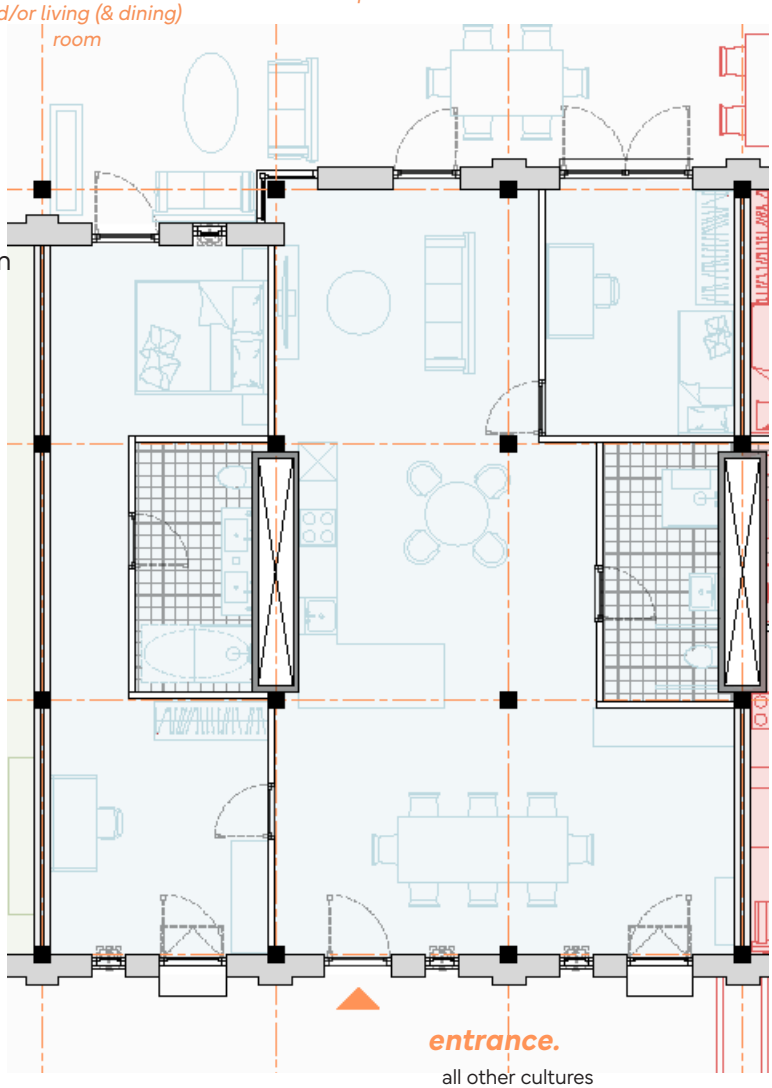


connected to kitchen and/or living (& dining) room

families & older couples/singles



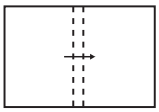
private



bedrooms.

at least 1 master bedroom (w/ ensuite bathroom)
1 'left over' bedroom, as guest room

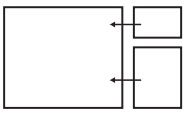
moroccan, indian, dutch, german & polish



preferably seperate, but studio is accepted when living alone

home office.

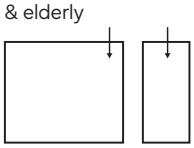
elderly



no office, but guest bedroom

bathroom & toilet.

couples, shared housing, families & elderly



seperate

kitchen.

dutch, german & polish

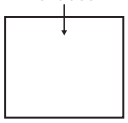


open

entrance.

all other cultures

front door



no need for buffer

home on ground-level due to mobility & preference for garden over terrace/balcony

the personas & their houses.

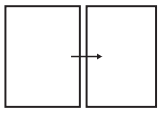
single (indonesian) elderly woman.

erita



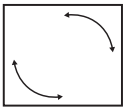
guest bedroom.
extra (shared) guest room for visiting friends & family

bedroom.
turkish, indonesian & chinese



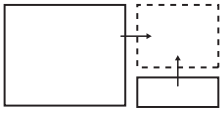
seperate (privacy is important)

bathroom & toilet.
(young) single person



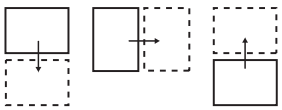
in same space

outside space.
indian, turkish, indonesian, dutch, german & polish

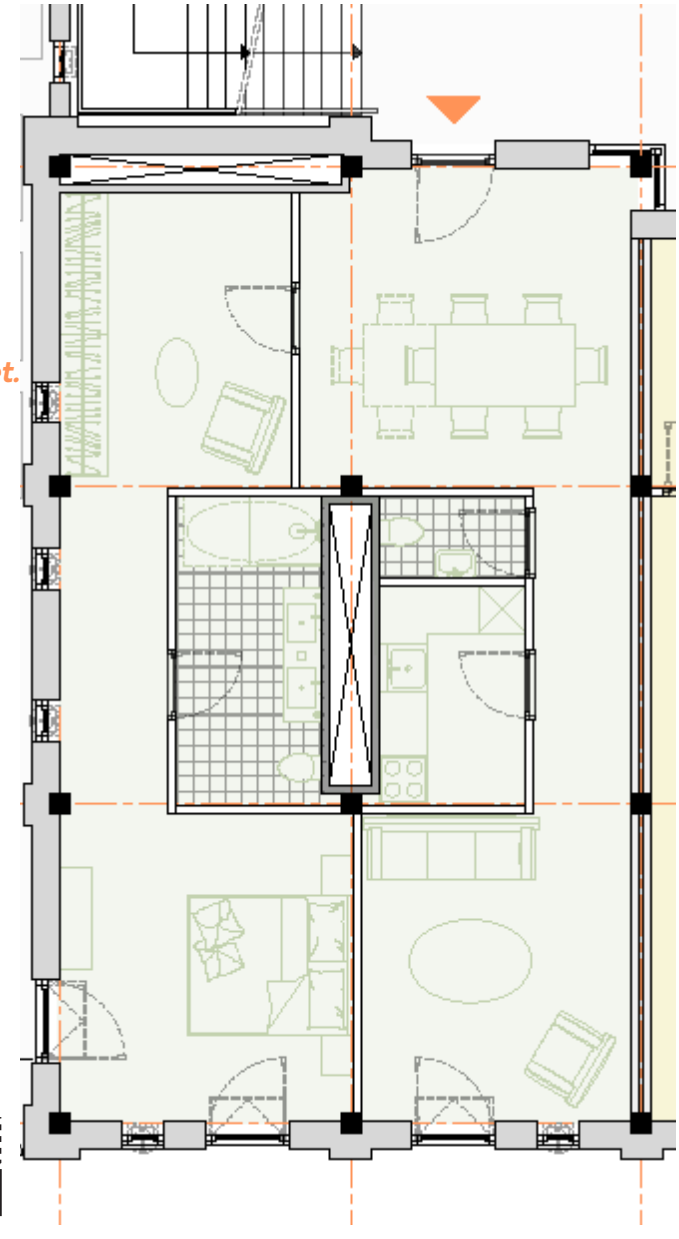


connected to kitchen and/or living (& dining) room

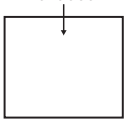
families & older couples/singles



private

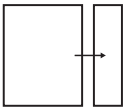


entrance.
all other cultures
front door



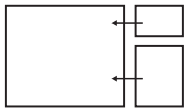
no need for buffer

kitchen.
turkish, chinese & indonesian



seperate

home office.
elderly



no office, but guest bedroom

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india analysis

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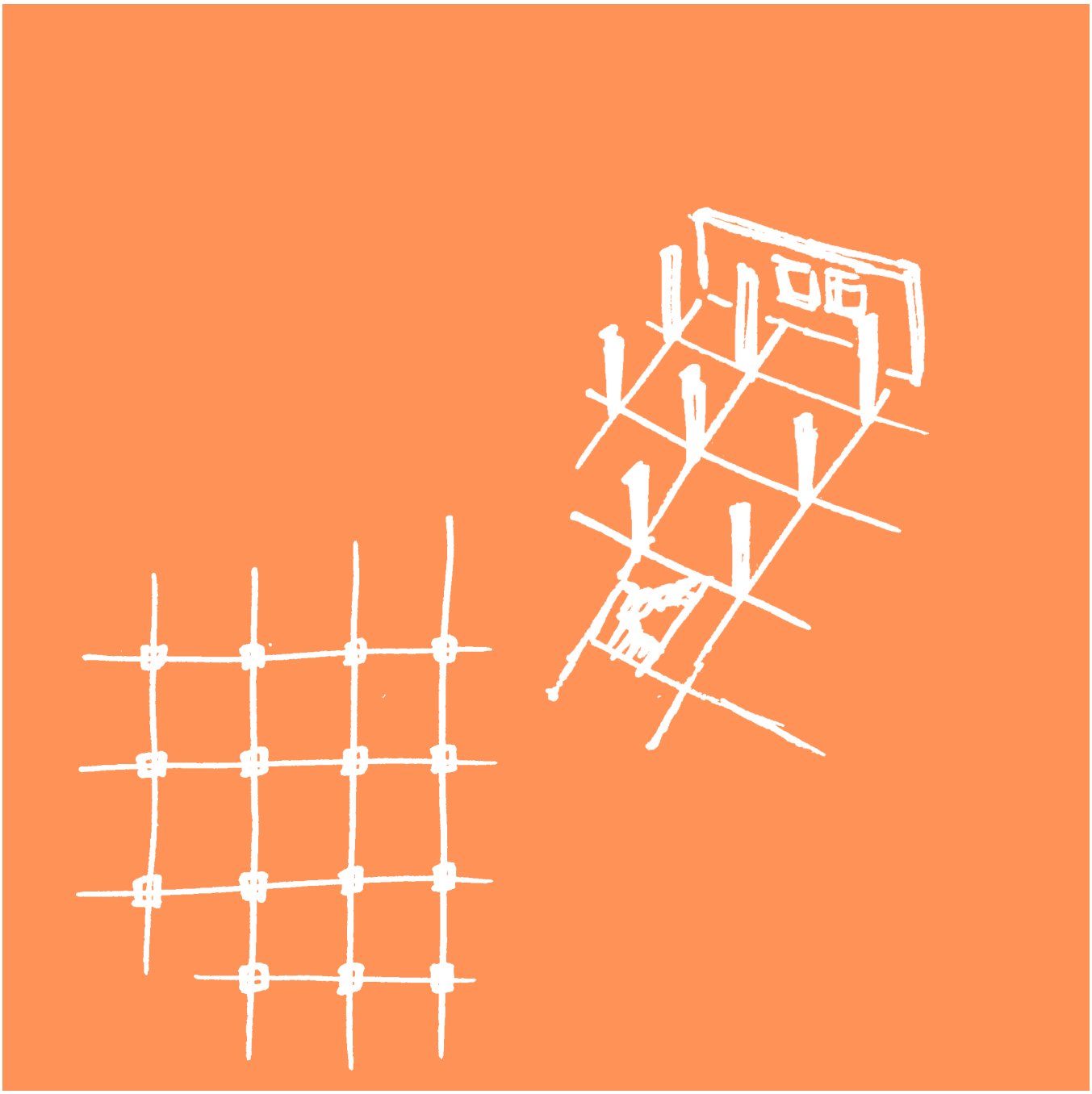
appendix b.

This appendix has been collected into a booklet. The booklet analyses 'open building' case studies (related to co-living or specifically adaptive houses). By also proposing design choices, the appendix finishes with a projection of these designs onto the desired function & within the context.



open-building studies.

based on **case-study analysis.**

april 2026

emma.
van barneveld.

tu delft
master thesis.

table of contents.

introduction. [4-5]

case-studies. [5-17]

- adaptive co-housing (master thesis).
- quinta monroy.
- modulus matrix.
- laan van de vrede.
- san riemo.
- la borda.

spatial testing. [18-23]

bibliography. [24]

introduction.

In previous paragraphs, we can identify the theoretical framework regarding the open-building concept. It derives from Habraken's theories, but Le Corbusier already started working with a more flexible frame. The basics of the framework entail the use of a fixed 'grid-system', where the structure is fixed and forms the skeleton of the building. This element is later defined as 'the structure' in theories by Duffy & Brand. These theories are summarised in the infographic on the right.

Throughout this booklet, the goal is to analyse case-studies that use this system. Many buildings have been designed using this method, which is why the selected cases are ones where the goal was either to allow residents to adapt or expand their house easily or where shared spaces are implemented within the dwelling block.

figure 1.0. *Overview of existing 'adaptive building' research & its influence. Author's work.*

intention ***to be adaptive***,

- **quinta monroy**, a chilean dwelling complex that was built 'unfinished' and intended for residents to add rooms when they had the money to do so
- **modulus matrix**, uses a grid based on japanese architecture that allows all rooms to have two sides from which to access the room, to minimise circulation both within and around the dwelling
- **laan van de vrede**, a proposed project where during construction each floor could be filled in differently, allowing for 4-5 different housing typologies within the same framework

intention ***to share spaces***,

- **adaptive co-housing (master thesis)**, is a project that allows for student rooms to be (re-)moved when the student finished their studies and to share service systems (like the kitchen & bathroom)
- **san riemo**, uses a grid to make the rooms along the facades, while the middle remains either the circulation space or the shared rooms, like the kitchen or the living room
- **la borda**, uses a grid that has two sizes, one for the wet cell and one for the other spaces which can be combined to form a dwelling while also facilitating shared spaces

Estaji (2017)
literature review of adaptive building theories

Le Corbusier
1914

Habraken
1961

Duffy
1990

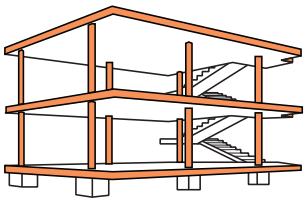
Brand
1994

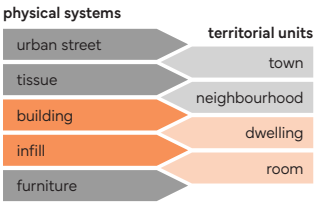
Maison Dom-Ino

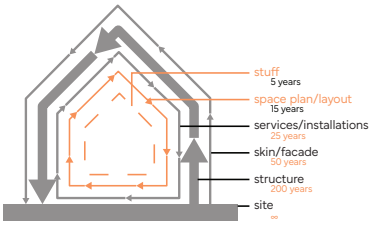
Open Building

Shearing Layers

revised & developed







structure is fixed

no load-bearing walls

difference between infill & building/support

aware of people's choices in the building

replacement of 'faster' layers shouldn't bother 'slower' layers

building adaptability affected by time

builds on

builds on

structure that doesn't damage easy, with small load-bearing elements

partion walls that can be (re)moved easily

floors that can handle some adaptation

reorganisation depending on material & lifespan of this material

case-studies

case-studies

'architecture should incentivice'

'it's important to make the user part of the process'

Hertzberger
1991

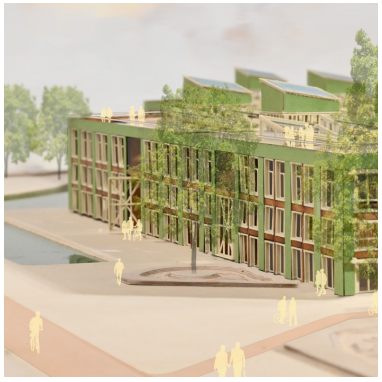
Schmidt III et al.
2010

figure 1.0.

adaptive co-housing (master thesis).

architect.	Daan Doelman (student)
year of completion.	2024
location.	Delft, the Netherlands
n° of dwellings.	548
dwellings size.	room is 9 m^2 (shared space)
grid size.	3x3m

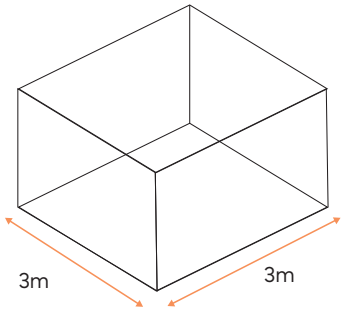
impression images.

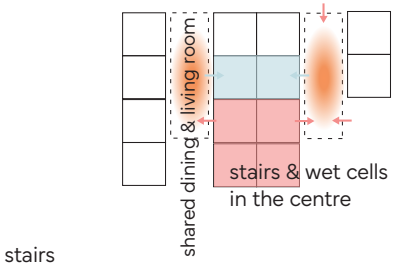






grid analysis.



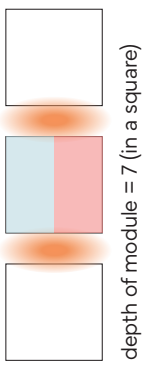


stairs
4 modules

bedroom
1 module

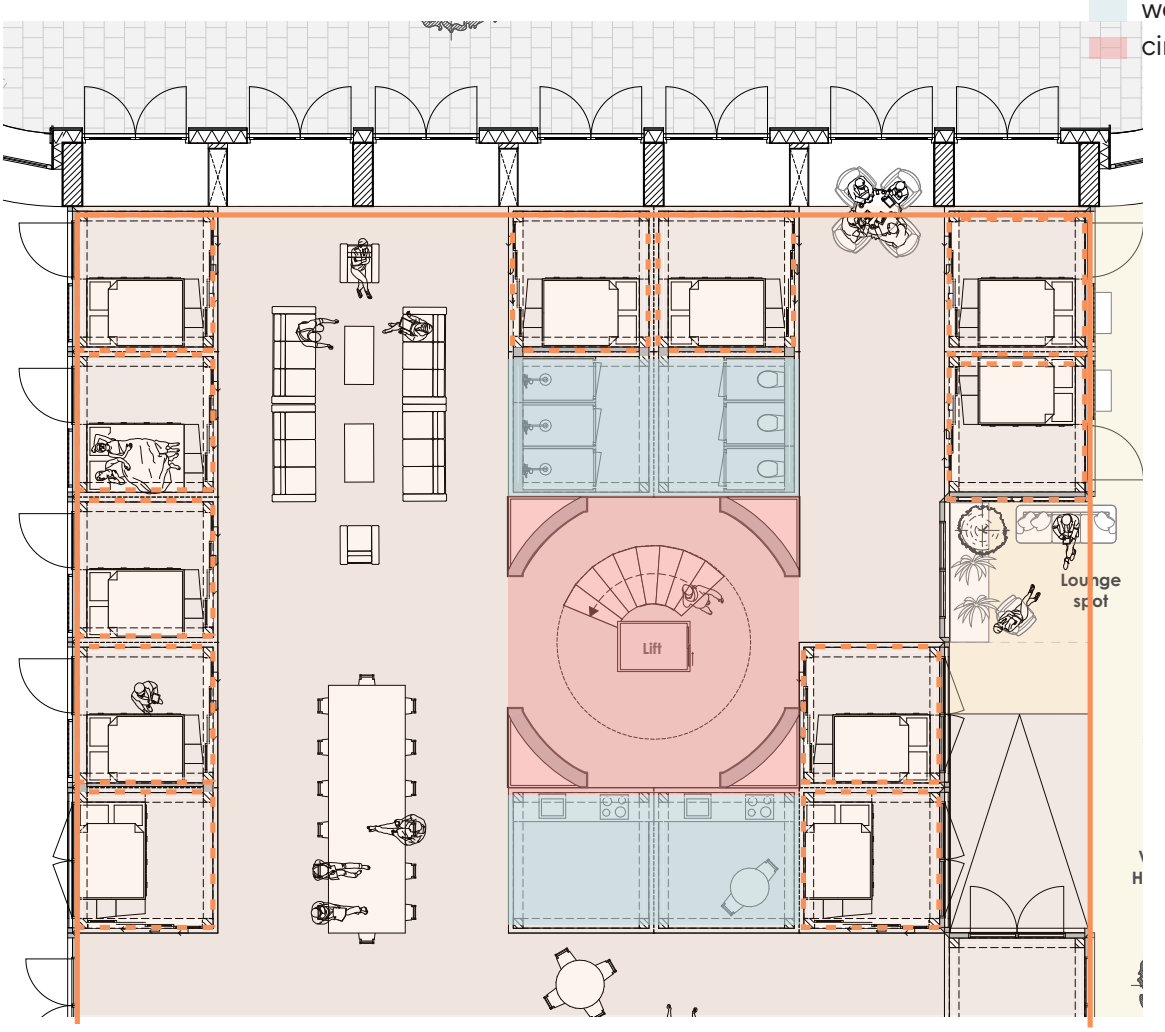
bathrooms
2 modules

kitchen
2 modules

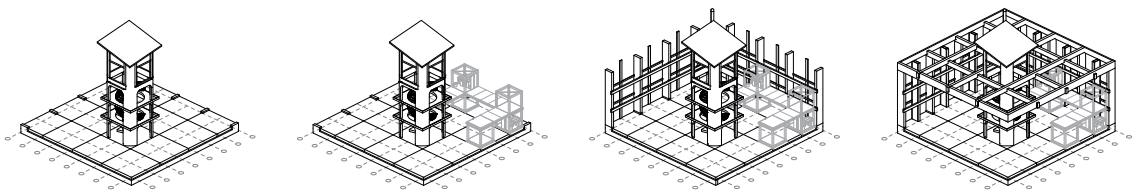


design floor plan analysis.

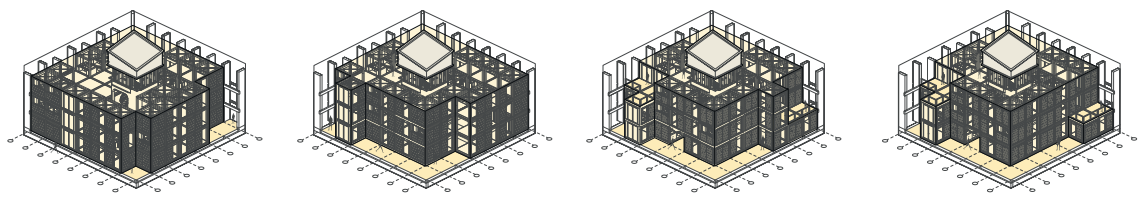
dwelling lines
wet cells
circulation



additional drawings.



Varying borders



quinta monroy.

architect.	Elemental Chile (with Aravena)
year of completion.	2004
location.	Iquique, Chile
n° of dwellings.	93
dwellings size.	54-108 m^2
grid size.	3x3.8m & 3x2.2m

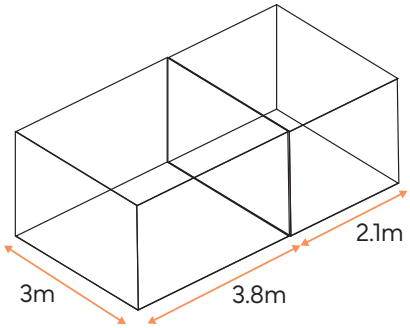
impression images.







grid analysis.

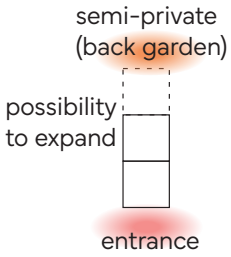


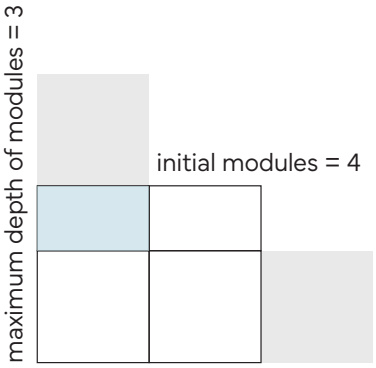
living room
1 big module

bedroom
1 big module

dining room
1 small module

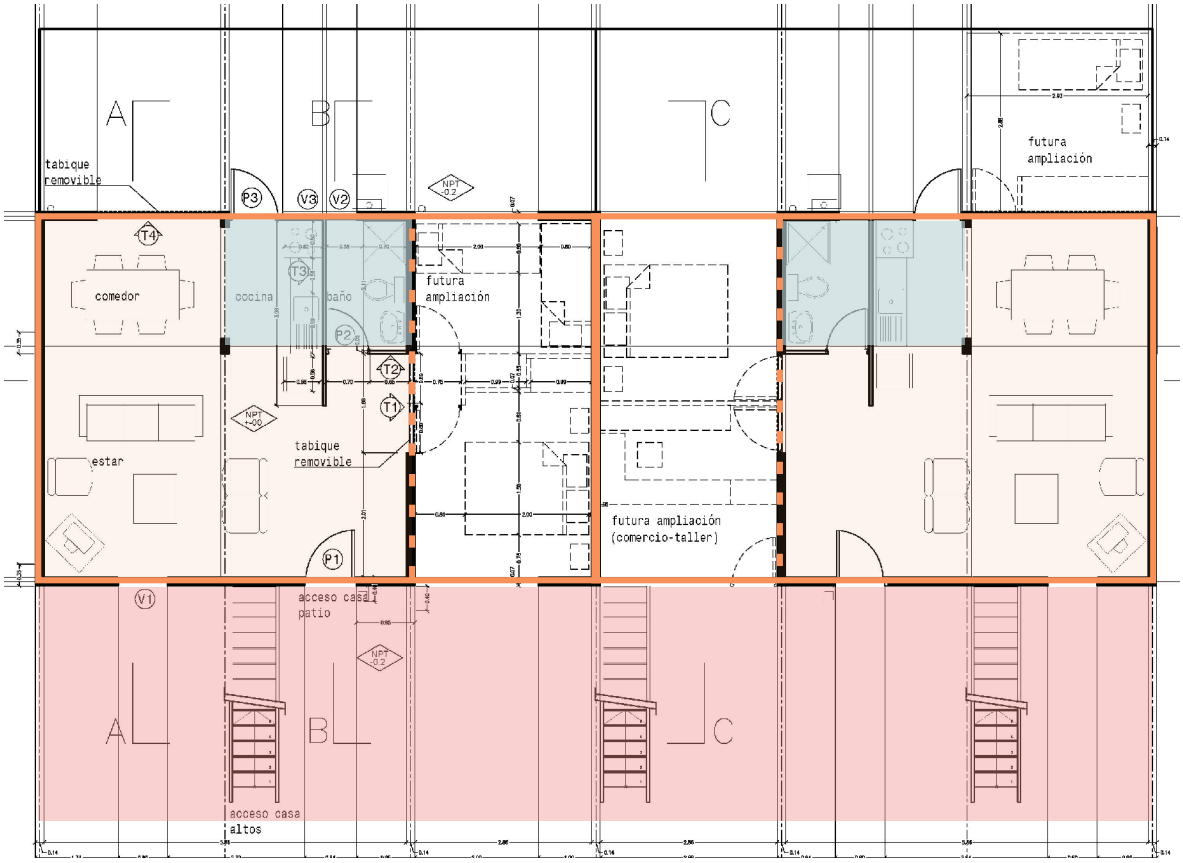
bathroom & kitchen
1 small module



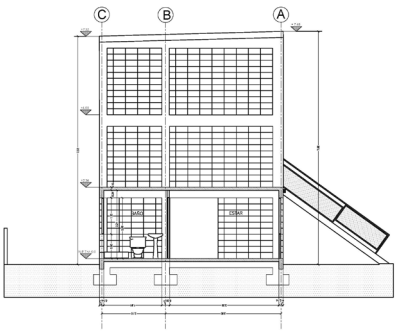


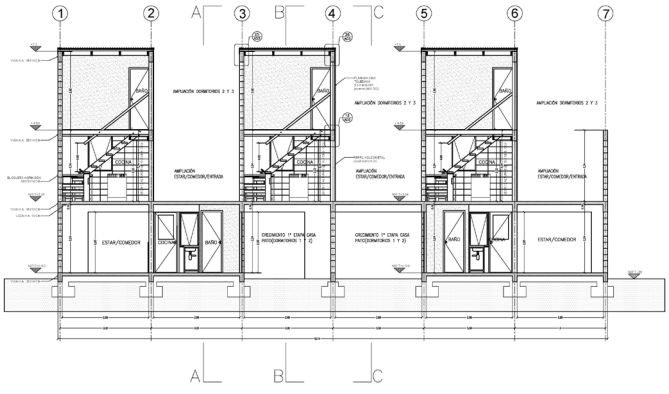
design floor plan analysis.

dwelling lines
wet cells
circulation



additional drawings.





modulus matrix.

architect.	Peris+Toral
year of completion.	2020
location.	Barcelona, Spain
n° of dwellings.	85
dwellings size.	58-78 m^2
grid size.	3.67x3.53m

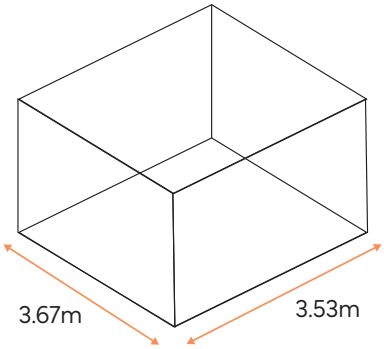
impression images.

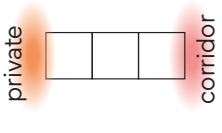






grid analysis.





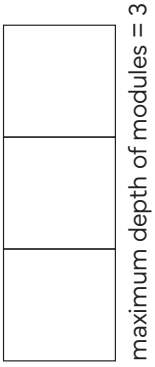
enclosed by gallery on both sides

bedroom
1 module

living room
1 module

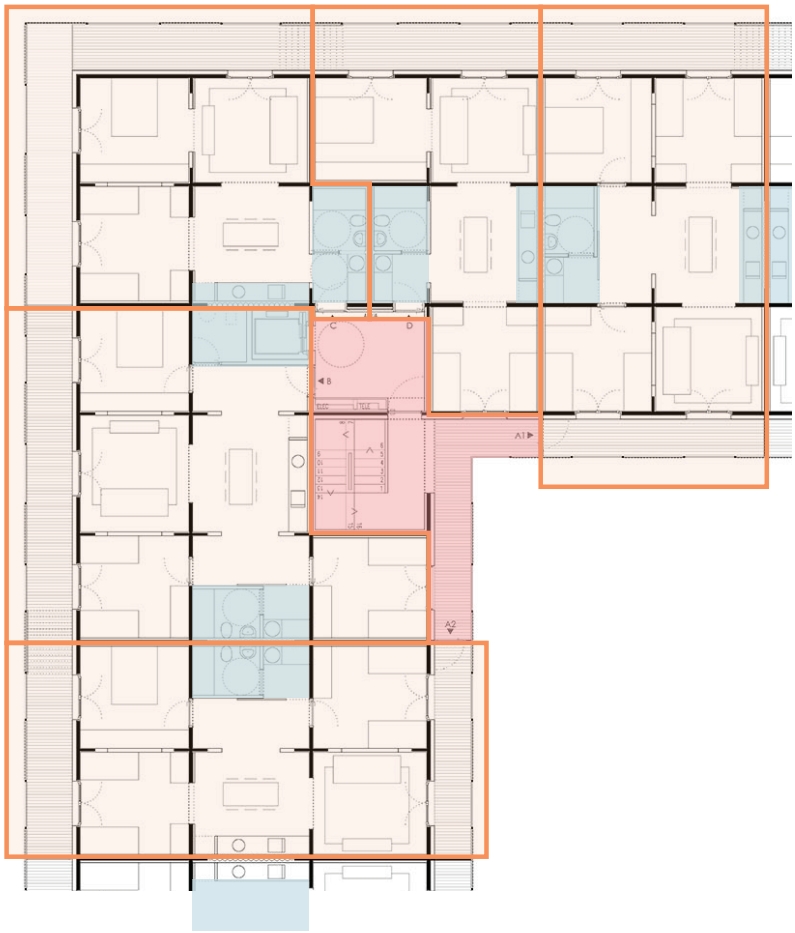
kitchen &
dining room
1 module

bathroom &
circulation space
1 module

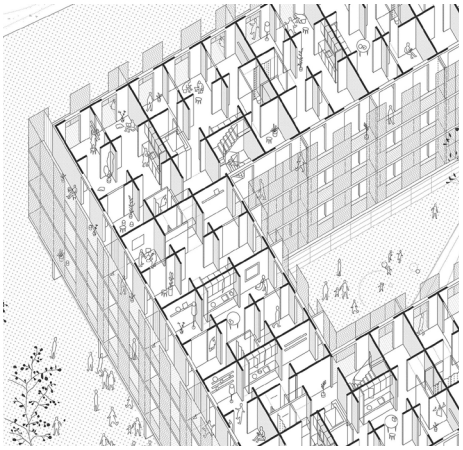


design floor plan analysis.

dwelling lines
wet cells
circulation



additional drawings.





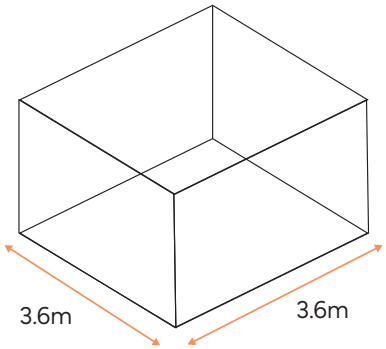
laan van de vrede.

architect.	De Zwarte Hond
year of completion.	Proposal in 2022
location.	TenHoorn, the Netherlands
n° of dwellings.	~400
dwellings size.	46-125 m^2
grid size.	3.6x3.6m

impression images.



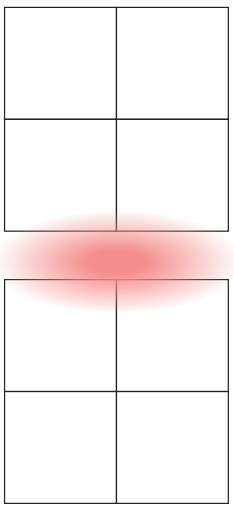
grid analysis.



bedroom
1 module

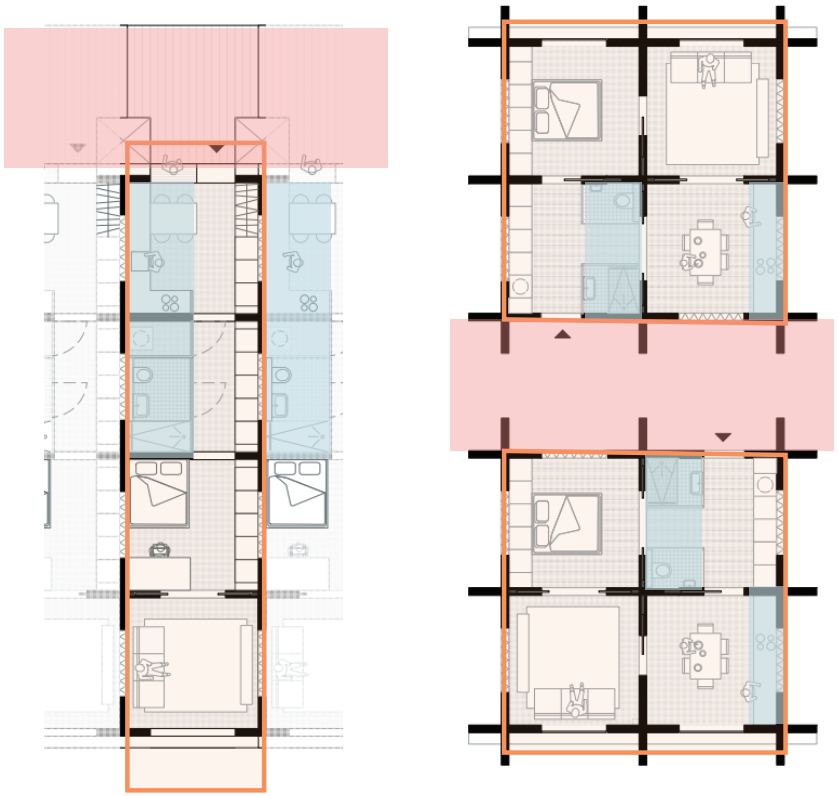
living room
1 module

kitchen by
itself or
along with
bathroom
or stairs
1 module

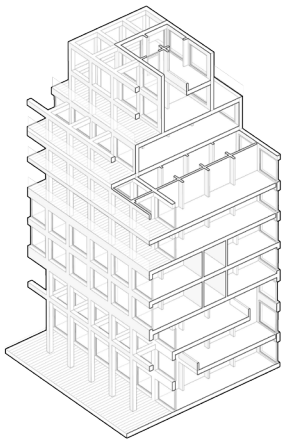


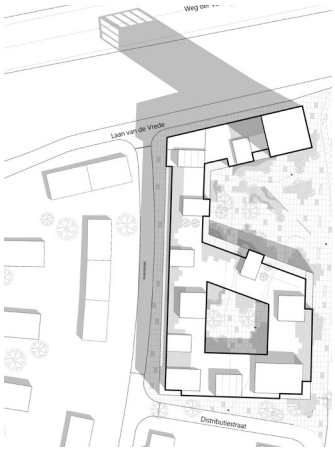
design floor plan analysis.

dwelling lines
wet cells
circulation



additional drawings.







san riemo.

architect.	SummaCumFemmer
year of completion.	2020
location.	Munich, Germany
n° of dwellings.	27
dwellings size.	room is 13.5 m^2 (shared space)
grid size.	3.6x3.8m

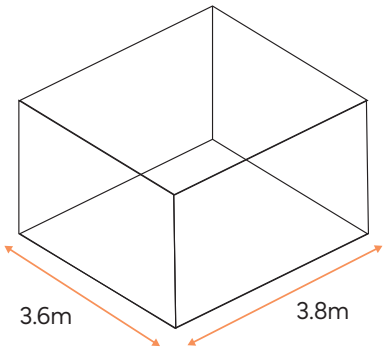
impression images.

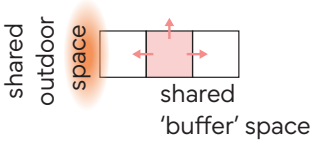






grid analysis.



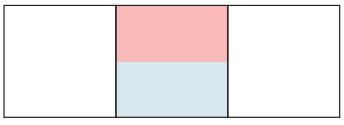


living room & dining
room always shared
(at least) 2 modules

bedroom
1 module

kitchen
1 module

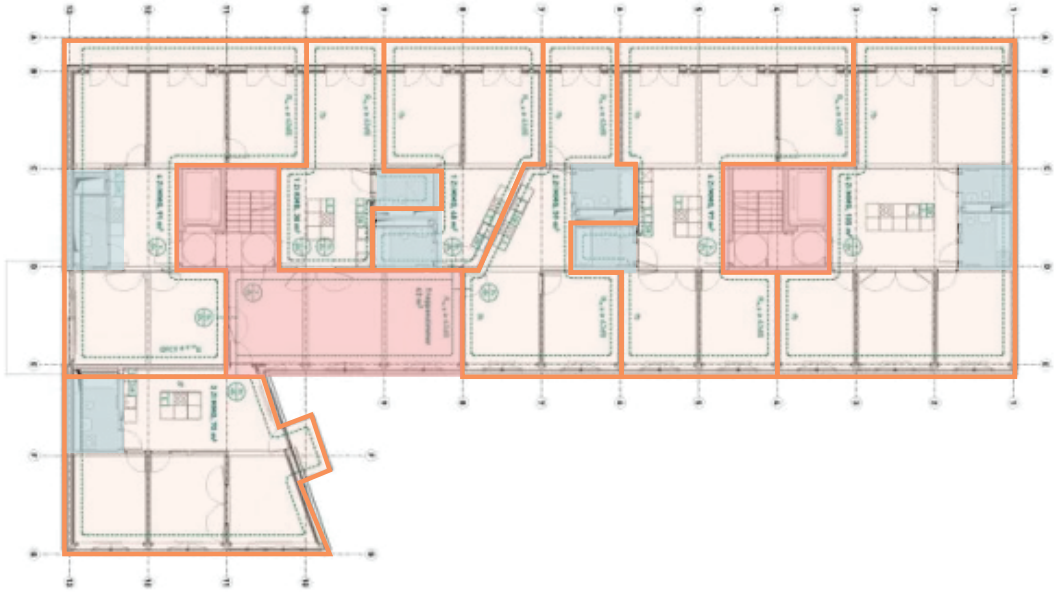
2 bathrooms
1 module



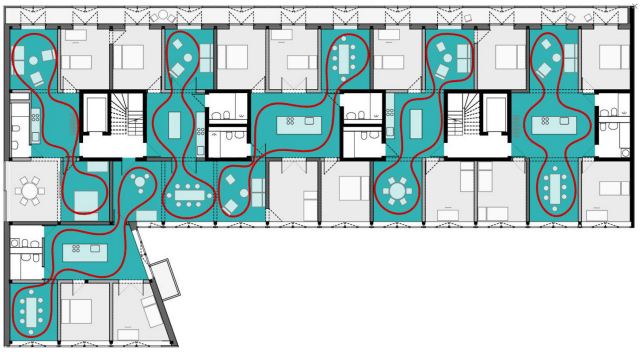
maximum depth of modules = 3

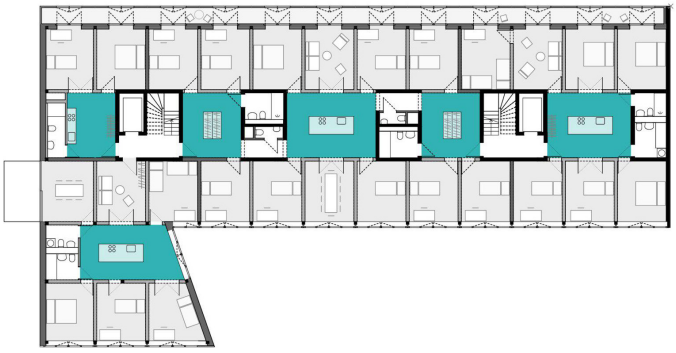
design floor plan analysis.

dwelling lines
wet cells
circulation



additional drawings.

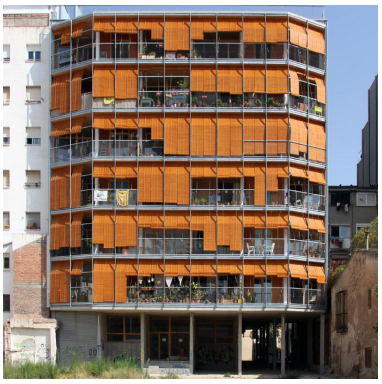




la borda.

architect.	lacol.
year of completion.	2018
location.	Barcelona, Spain
n° of dwellings.	28
dwellings size.	40, 60, 75 m^2
grid size.	3.8x4.1/4.2/4.7m

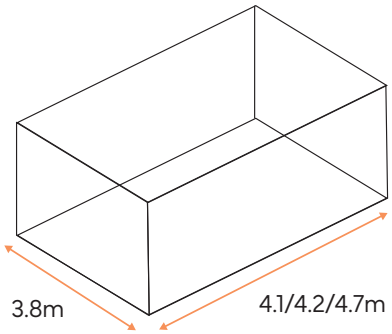
impression images.

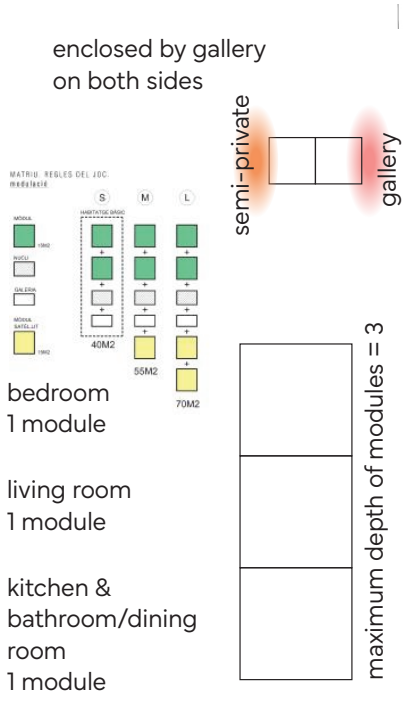






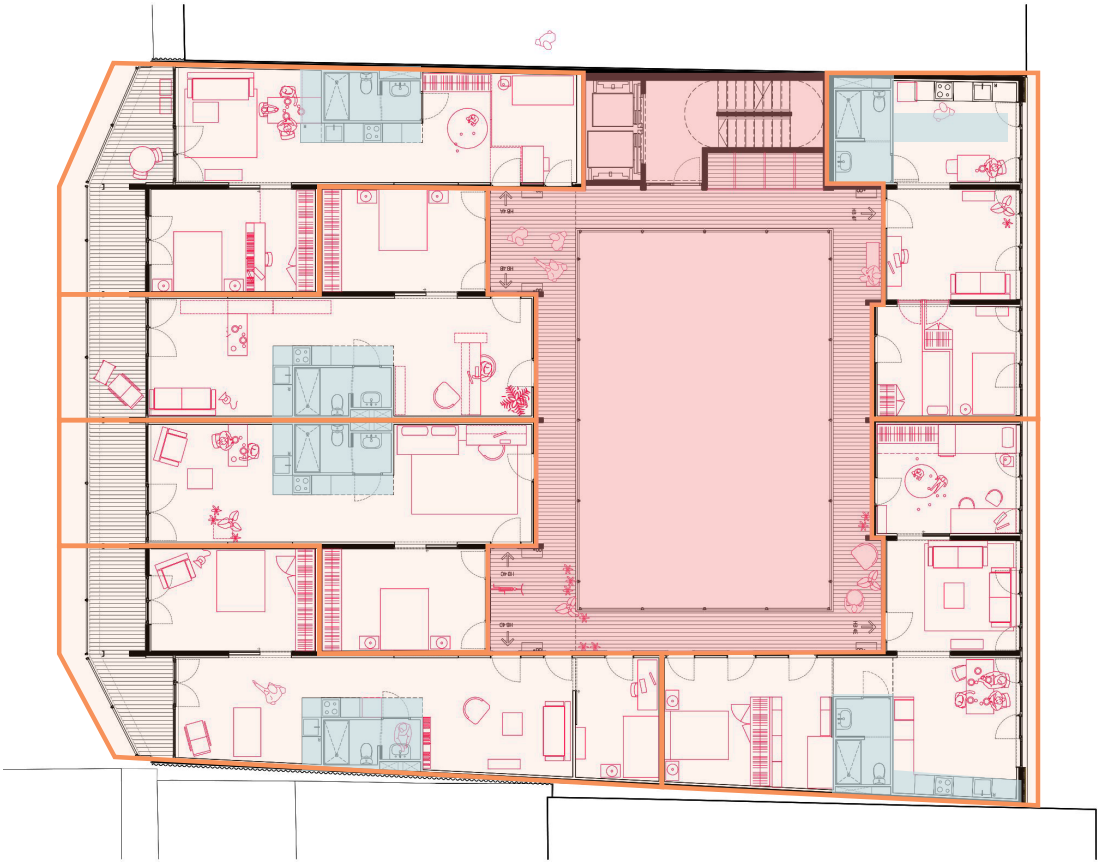
grid analysis.



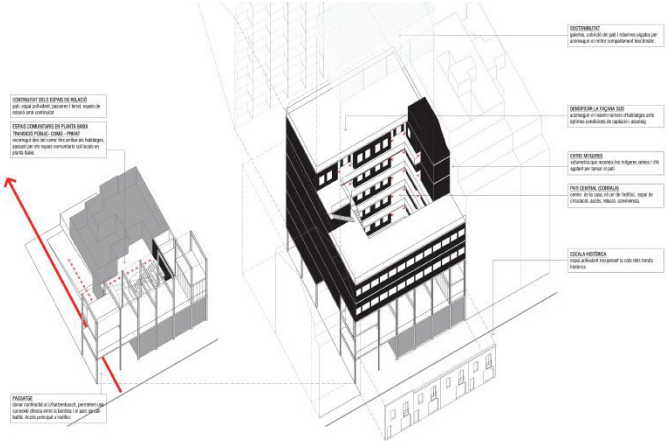


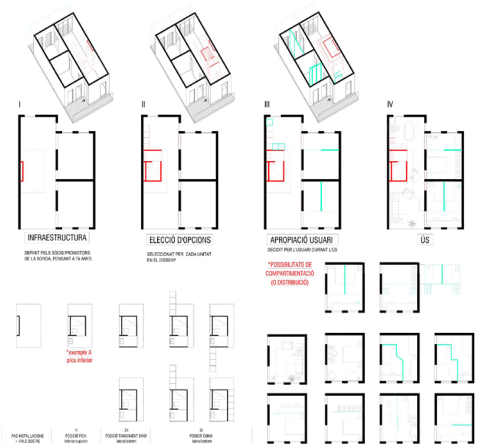
design floor plan analysis.

dwelling lines
wet cells
circulation



additional drawings.





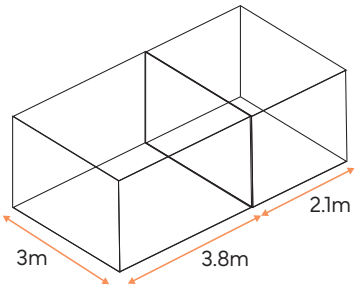
spatial testing.

After having gone through the case-studies, the research is translated into a series of tests. The grid sizes were all drawn out, and each space that a resident might need was tested within this grid. In most cases, the wet cell (containing the bathroom (& toilet) and kitchen) takes up one grid unit, which is why this research has approached the testing in the same way. The (master) bedroom is taken as the baseline space, since this is universal and the same among all ages & (studied) cultures.

When browsing through the different grid options, it is evident that working with smaller sizes, like 3x2.2m or 3x3m, makes it harder to fit certain rooms within that same grid (like a dining room or a wet cell). Of course, when designing with an open-building principle, the point is that walls don't have to fit within this grid, but for the design to allow flexibility within the layout, keeping to this grid or to equal parts of the grid is essential. For flexibility to work both ways within the floorplan, using a square grid, as opposed to a rectangular grid, can also be deemed essential for the adaptability of the walls. Nonetheless, if the rectangular lengths are a multiple of the same number, the flexibility would still be relatively easy to apply. For some rooms, biggest grid size is unnecessarily large, which can compromise the densification within the dwelling project.

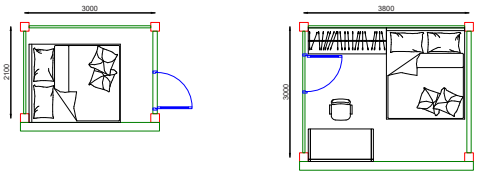
Additionally, in choosing the grid size, cultural and age-related spatial requirements are also taken into account. Requiring a closed kitchen (a kitchen in a separate room) or a bedroom with a double bed and wardrobe is essential in some cases, which is why, for example, the smaller sizes can be disregarded.

Conclusively, after having taken into account all these aspects, **a grid of 3.6x3.6m or bigger should be chosen** to further design within the project.

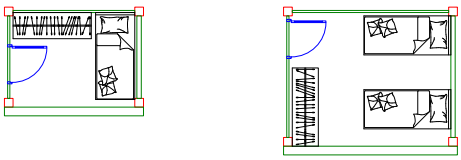


quinta monroy.

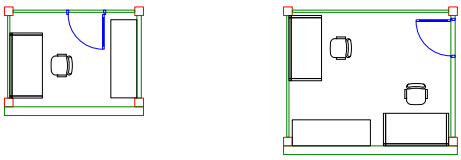
grid size is 3x3.8 m & 3x2.2 m



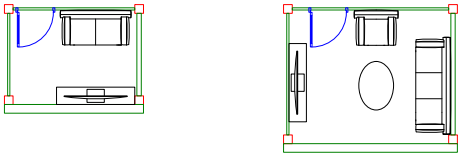
bedroom with double bed



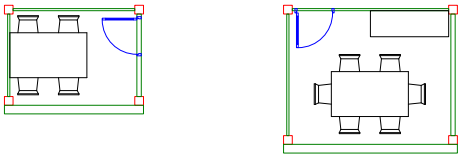
bedroom with (two) single bed(s)



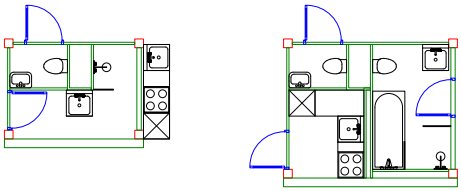
home office



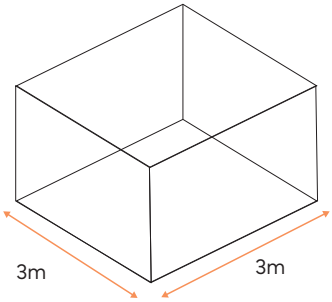
living room



dining room

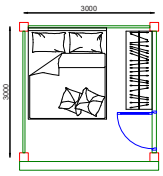


wet cell (bathroom & kitchen)

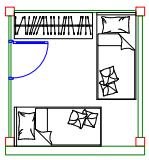


adaptive co-housing (master thesis).

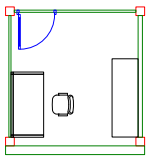
grid size is 3x3 m



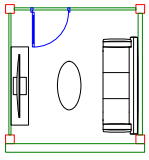
bedroom with double bed



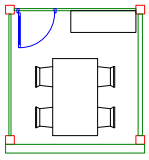
bedroom with (two) single bed(s)



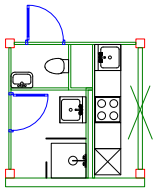
home office



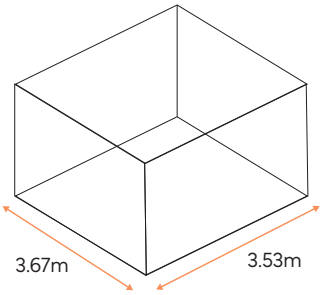
living room



dining room

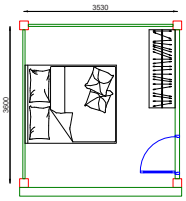


wet cell (bathroom & kitchen)

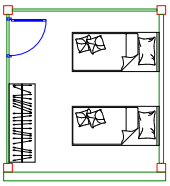


modulus matrix.

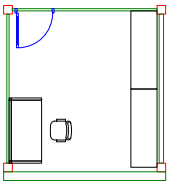
grid size is 3.67x3.53 m



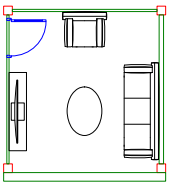
bedroom with double bed



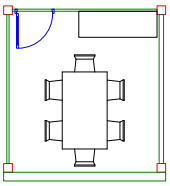
bedroom with (two) single bed(s)



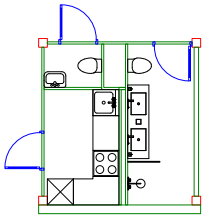
home office



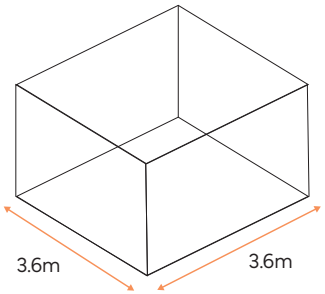
living room



dining room

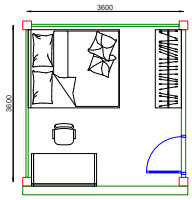


wet cell (bathroom & kitchen)

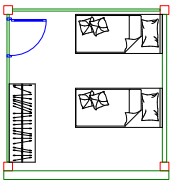


laan van de vrede.

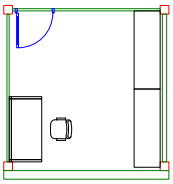
grid size is 3.6x3.6 m



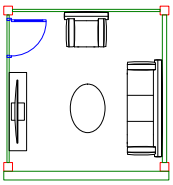
bedroom with double bed



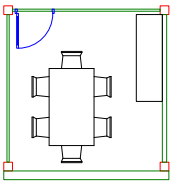
bedroom with (two) single bed(s)



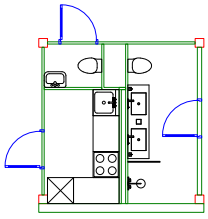
home office



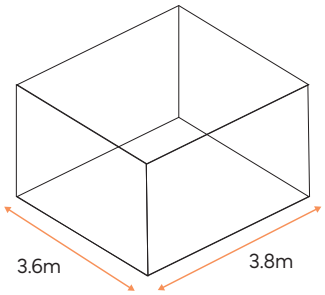
living room



dining room

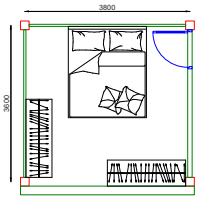


wet cell (bathroom & kitchen)

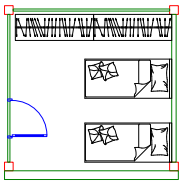


san riemo.

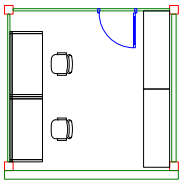
grid size is 3.6x3.8 m



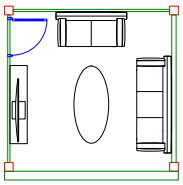
bedroom with double bed



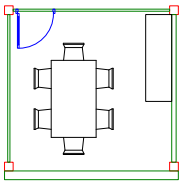
bedroom with (two) single bed(s)



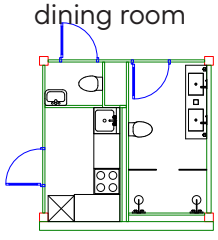
home office



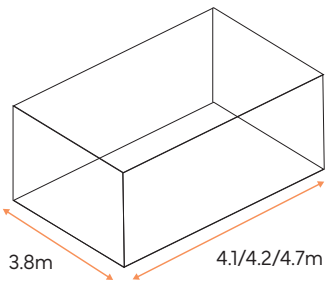
living room



dining room

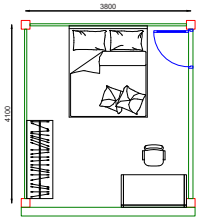


wet cell (bathroom & kitchen)

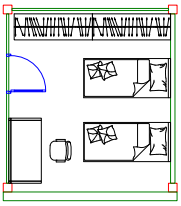


la borda.

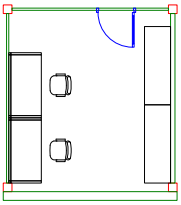
grid size is 3.8x4.1 m



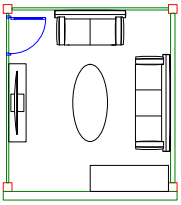
bedroom with double bed



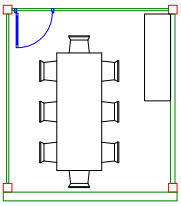
bedroom with (two) single bed(s)



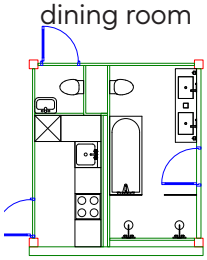
home office



living room



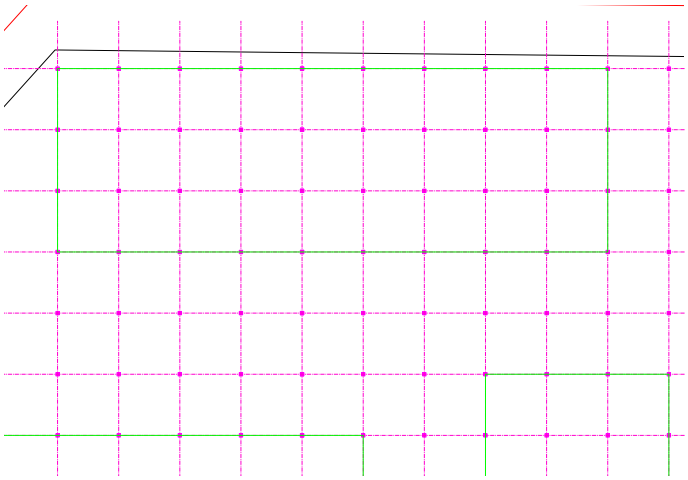
dining room



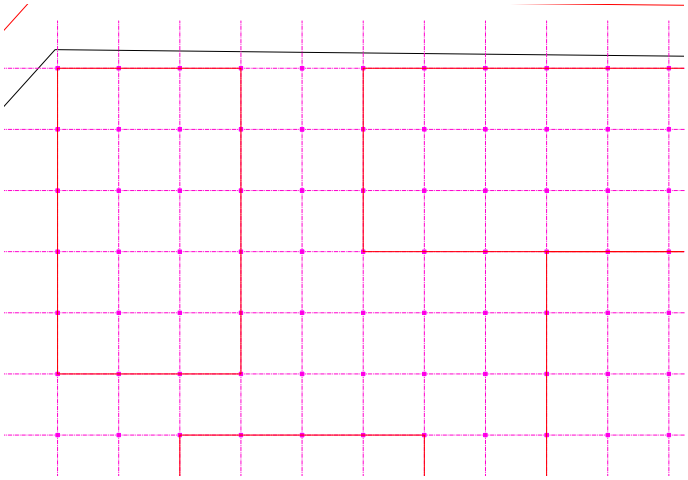
wet cell (bathroom & kitchen)

spatial testing (cont.).

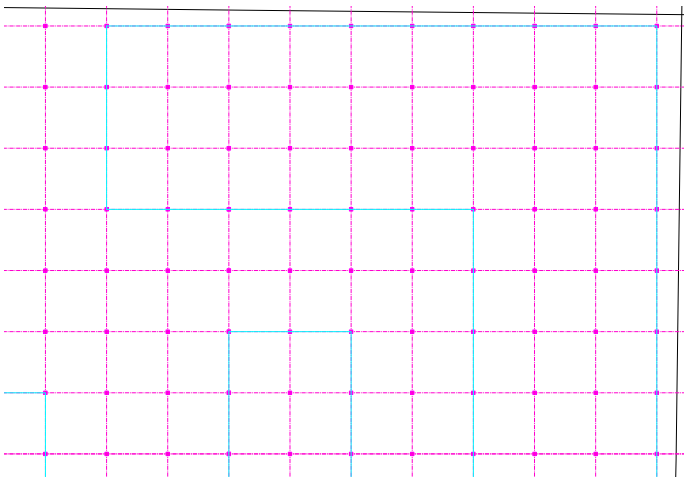
The following drawings show preliminary synergic testing of the choosen grid size 3.6x3.6m along with the massing typologies.



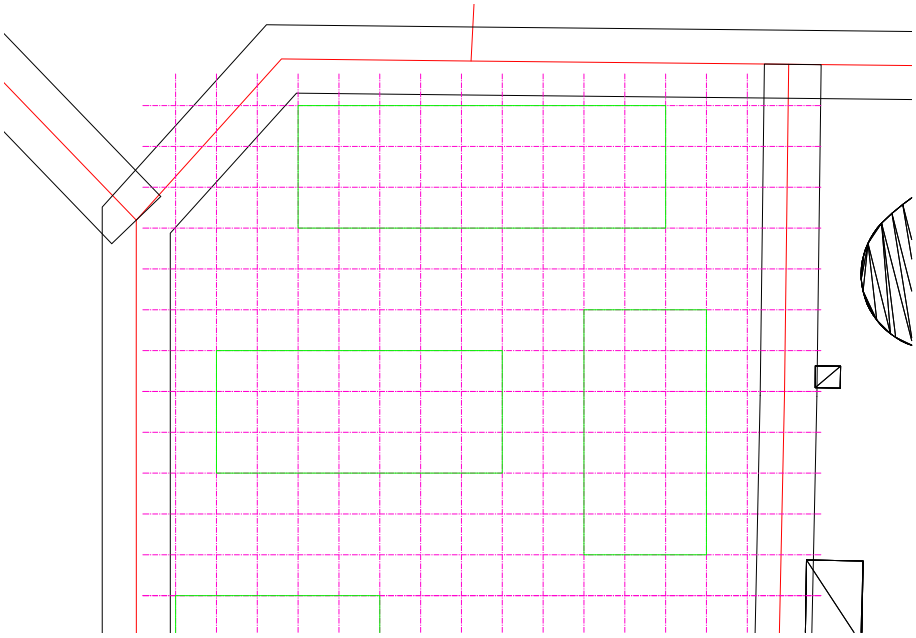
guest house.



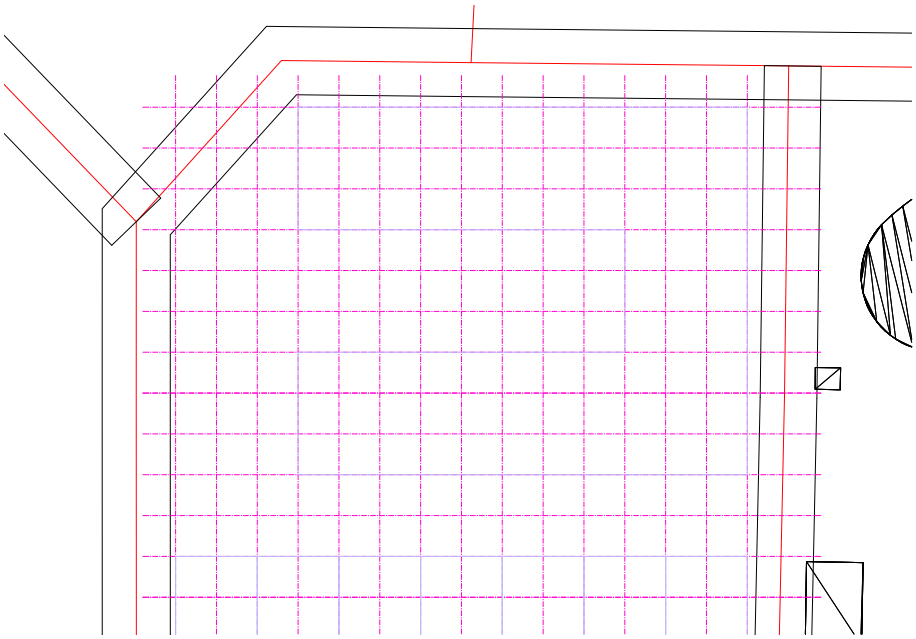
(open) courtyard.



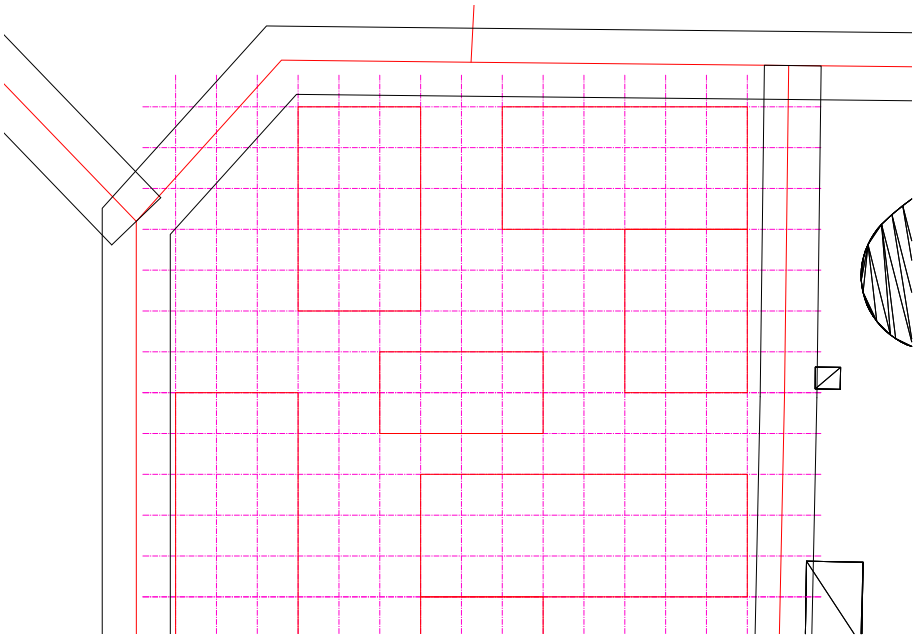
(closed) courtyard.



guest house.



gallery.



(open) courtyard.

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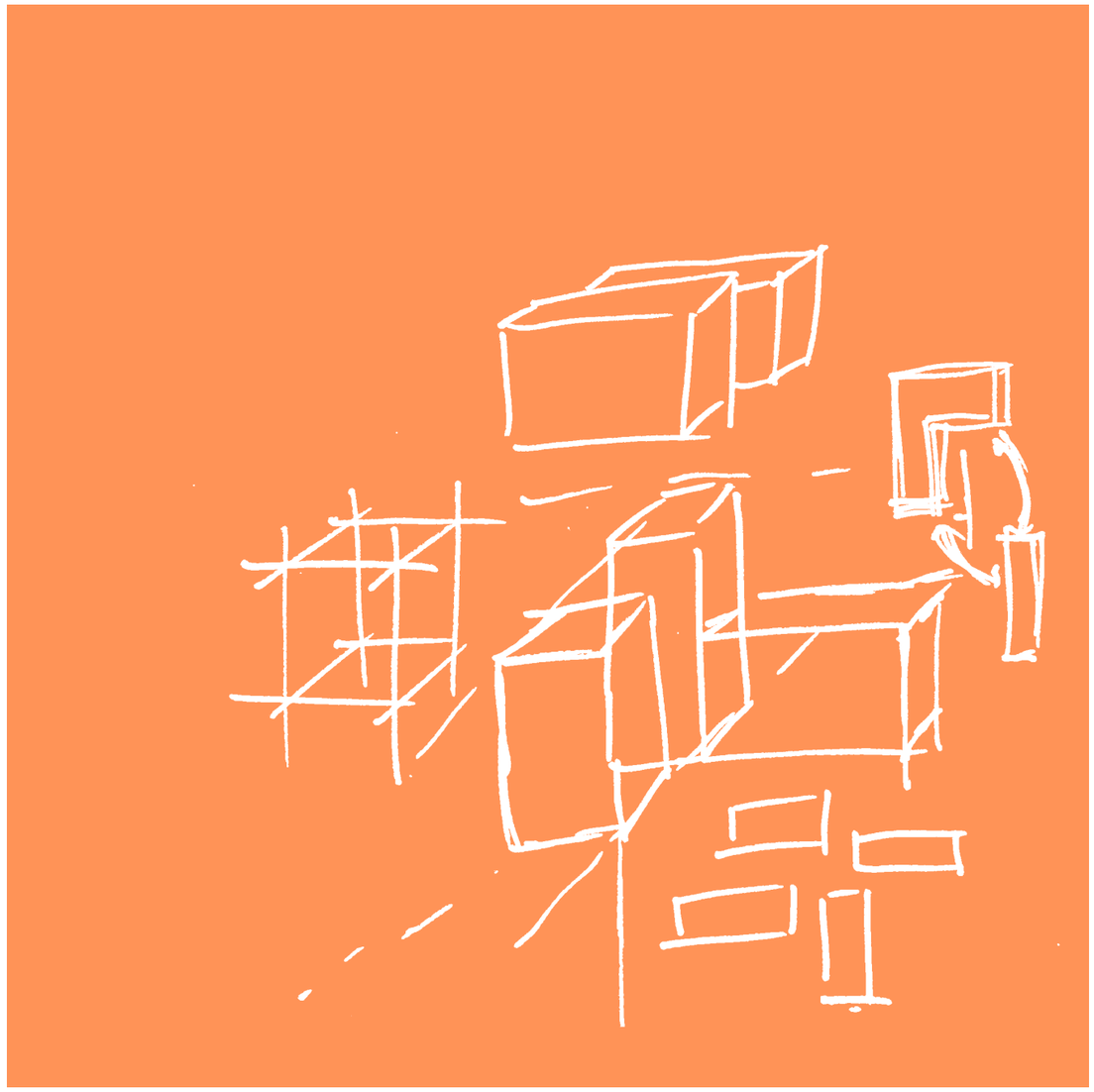
appendix c.

This appendix has been collected into a booklet. The booklet gathers 3 different co-living typologies and defines their associated design principles. These analyses, along with the theoretical framework, allow for these typologies to be projected in the form of volumes, floor plans & sections, to understand their added value.



massing studies.

based on **co-living principles.**

emma **van barneveld.**

april 2026

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puu-käpylä.
meer&deel.
la borda.
modulus matrix.

introduction.

Looking into the theories behind co-living, such as those described by Gehl (2010), Vestbro (2010), Uyttebrouck et al. (2020) & Czischke et al. (2023), it is evident that some requirements are more likely to lead to success than others. To argue the massing studies that have been done, the main requirements are summarised below.

The ***circulation*** should be...

1. **visible**, people should be able to see their neighbours leaving or getting home (whether it's a corridor or a gallery)
2. **clear**, allowing for neighbours to walk past each other without overstepping in other's space
3. **going past the collective spaces**, this allows people to know whether there are people there without explicitly having to check, which makes it more inviting

The ***scale of the blocks*** should...

1. **not exceed 4-5 floors**, since from a higher point people cannot recognise who's walking at the ground floor level
2. **be separated by a maximum of 12.5m**, since from this distance people can still recognise the neighbours entering their apartment on the other side
3. **be about 25m from the surrounding buildings**, to ensure familiarity with the existing context and neighbours

The ***shared space*** should be...

1. **on opposite ends**, to make sure that neighbours on either side of the building plot can access it
2. **visible**, from either the home or from the entrance
3. **defined clearly**, there should be no confusion over either what is public, collective and private, nor over who 'owns' it and maintains it
4. **shared with 4 to 5 households**, if they do not have this space within their own private home (say, a kitchen or a bathroom)

co-living typologies.

Over the years, co-living and the concept of sharing within the home have always been present. We can see this concept all the way back in 1925, with the Puu-Käpylä complex in Helsinki, as well as the recent La Borda in Barcelona (completed in 2018). The reason that sharing has been slowly lost within dwellings mainly comes due to the switch in the social & political context. When people were able to afford their 'own' things, people wanted their own things. This can be seen within the dwellings market, as well as within the vehicular market or the clothing market (Santos et al., 2017).

When analysing co-living complexes, there are certain typologies that are clearly more common than others. Four main typologies have been identified based on case-study analysis.

the guest house.

This typology is based on both meer&deel (in Eindhoven, realised in 2024) and the Puu-Käpylä complex in Helsinki (realised in 1925). It can be characterised by:

- it being **low-rise**, in Helsinki, it is often only 2-floor buildings, and in Eindhoven, no more than 4
- there being **several 'smaller' blocks**, there isn't one big building but rather several buildings (with a maximum of 10 households per block) that are linked
- the **outdoor space is always on the ground floor,** and its form is mainly a garden along the linked circulation paths between the blocks
- a **human-scaled facade**, like there being (narrow) wooden cladding or separate windows as opposed to a big glass facade
- a **pitched roof** as opposed to a flat roof, relating to the concept of 'a single house'

the gallery.

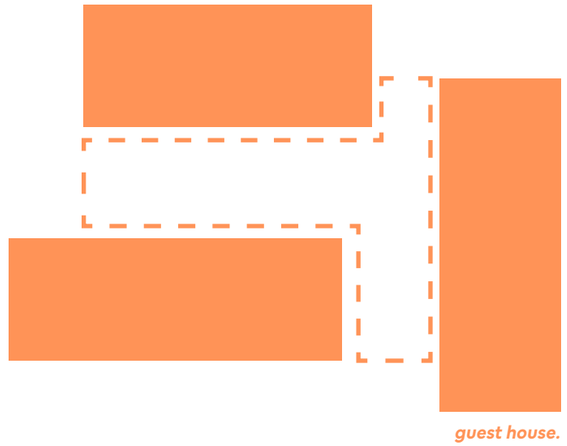
This typology is based on both La Borda (in Barcelona, realised in 2018) and Modulus Matrix (in Cornellà, realised in 2020). It can be characterised by:

- the **circulation space being on the inside** of the building, that wraps around interior courtyard
- there being **two sides to the building**, a gallery that wraps around on the outside, offering private exterior space as well as having a gallery that wraps around the interior courtyard that serves as a collective outside space
- the households all being clustered within **one big building block**
- the **ground floor having a seemingly public function**, people walking past can either see through the building or interact with the building at ground floor level

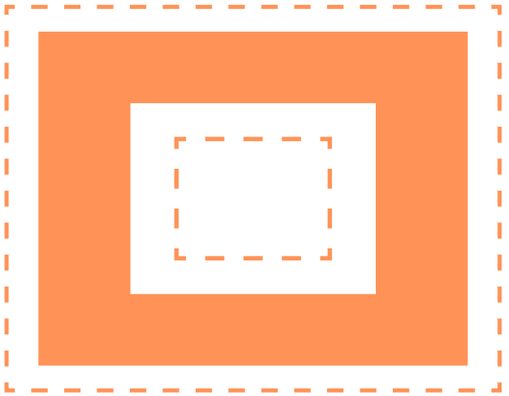
the courtyard.

This typology is based on the 'bloemkolwijken' in the Netherlands. This typology has been studied through the in-depth research done by Bron et al. (2021). This booklet, show two tested forms of this typology: the open courtyard and the closed one. Many of the case-studies related to this typology offer two types of blocks: one with a courtyard faced outwards (an open courtyard) focused on the collectivity between several blocks, while the other is faced inwards (a closed courtyard) focused more on the collectivity within that same block. This typology is characterised by:

- the **cauliflower shape of the building block**, the block is a series of row houses that are all facing a specific centre (or courtyard), which is why they create interlinked hexagons
- it being **extremely low-rise**, in most cases the buildings never exceed the 2 floors (and sometimes they also have an attic)
- the **possibility to mirror all floors**, due to the wet cell & circulation space being in the middle of the house
- there being **a collective front of the house**, and a **private garden at the back** of the house
- the amount of green that surrounds the houses
- **the back of the house usually allowing for a** (car) storage **attached as a volume to the house**, to privatise the back of the house



guest house.

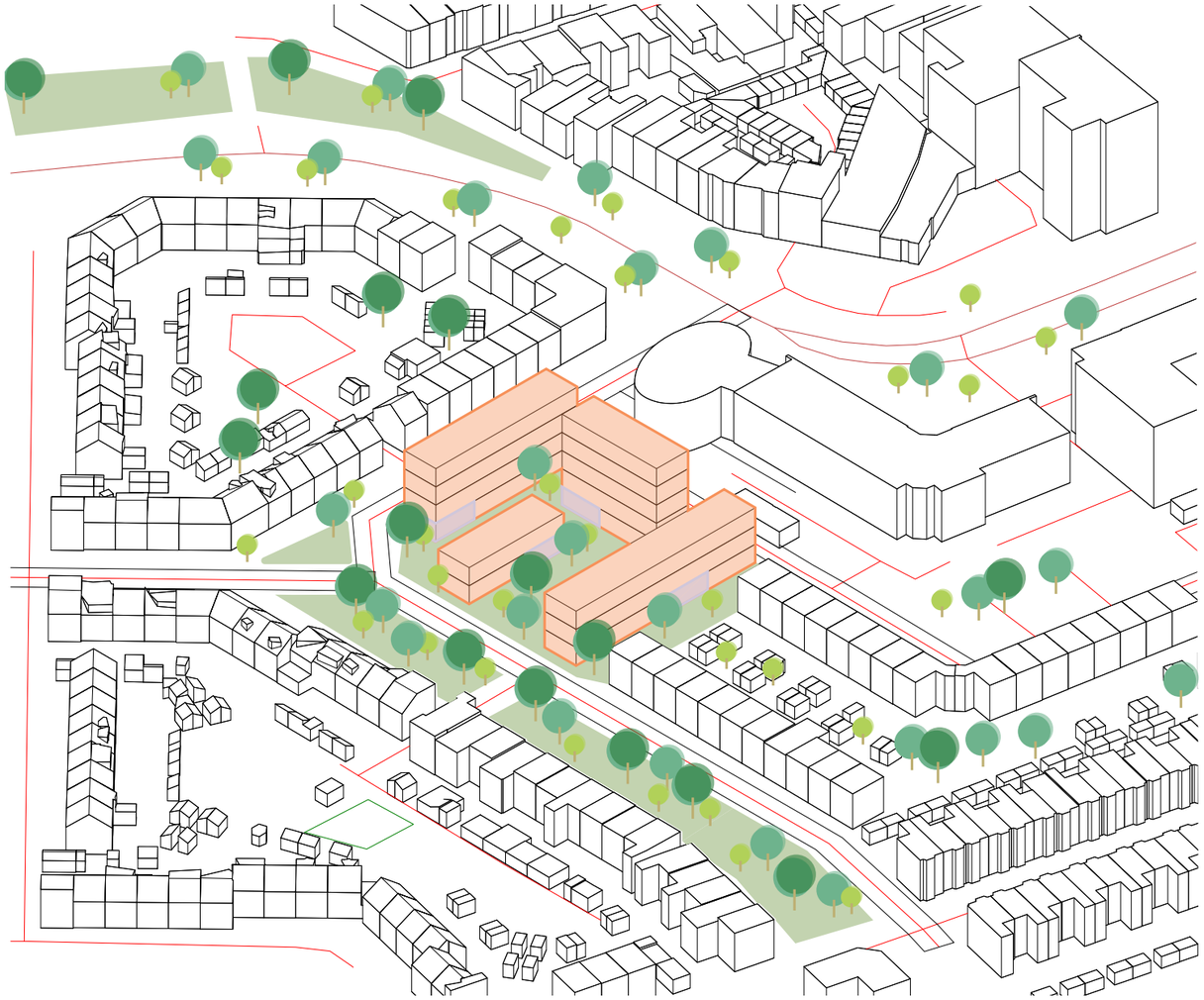


the gallery.



the courtyard.

typology a | guest house.



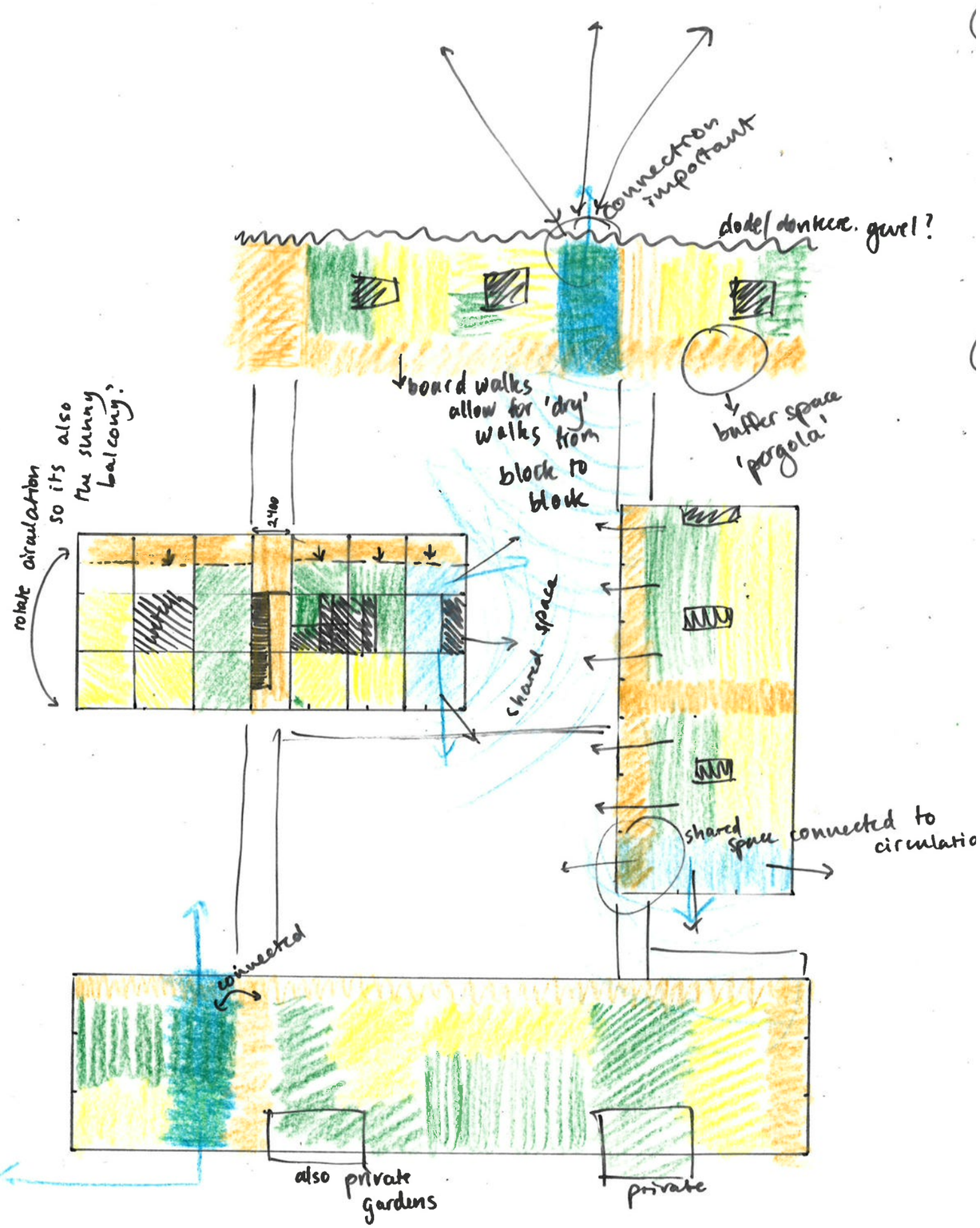
positives

+ creating a buffer zone that functions as a gallery allows for a more private entrance to the home (even adding volumes on some spaces to make little inlets allows people to have a more private space at the gallery
+ boardwalks allow for dry passage from house to house & as a buffer space
+ it's easier to make shared space & create ownership regarding this space due to it being within a block
+ no 'odd' corners, due to the volumes (easier with the grid system)
+ easy to design a variety of houses within the same volumes

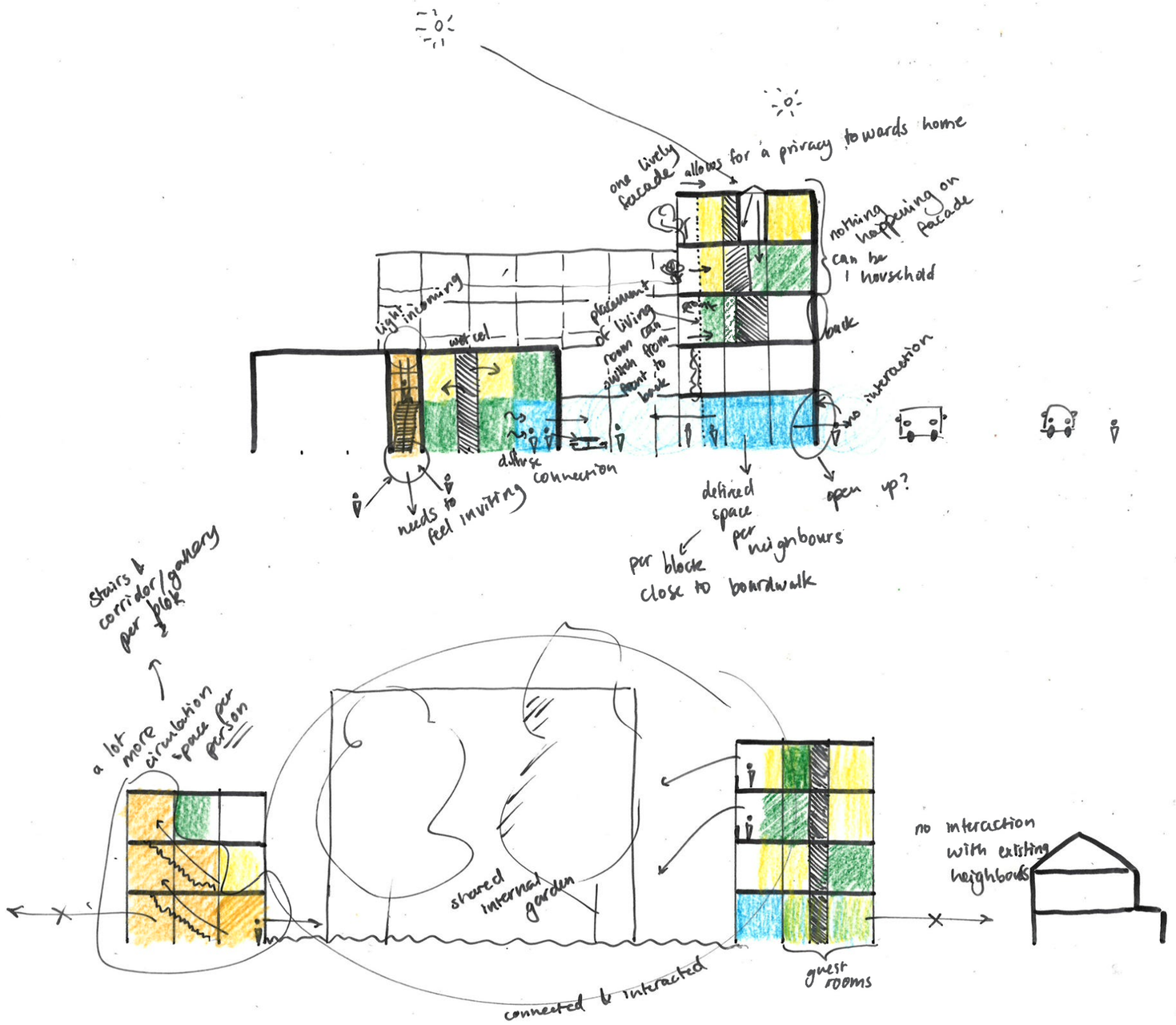
negatives

- internal circulation increases due to various blocks with their own stairs
- little interaction with existing neighbours
- there's a front and a back to the building block
- no private gardens, balconies - there needs to a be a lot more agreement on who takes care of what and what can be used by whom
- blocks need to become relatively high in order to facilitate a high density complex

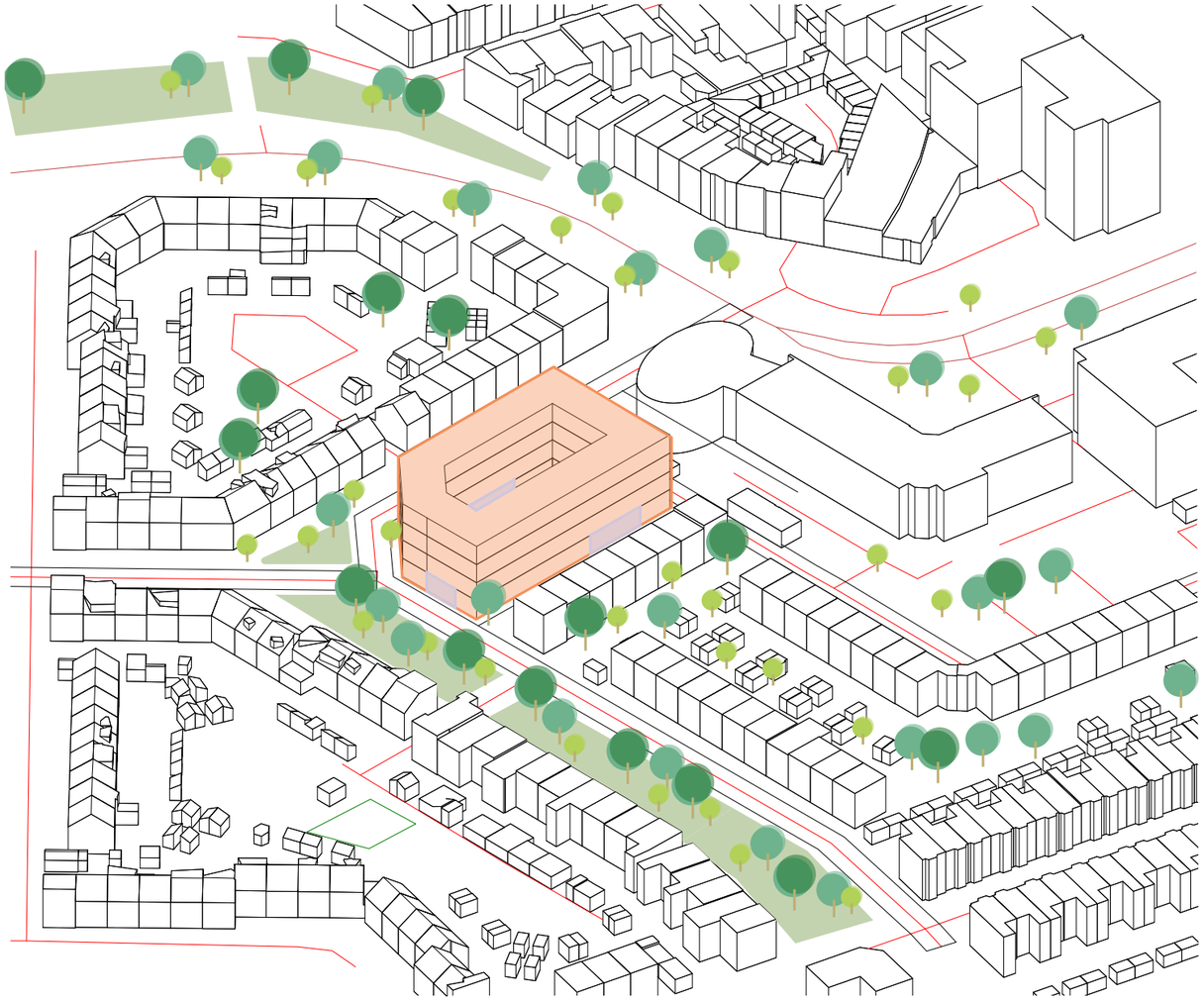
typology a | guest house.



typology a | guest house.



typology b | gallery.



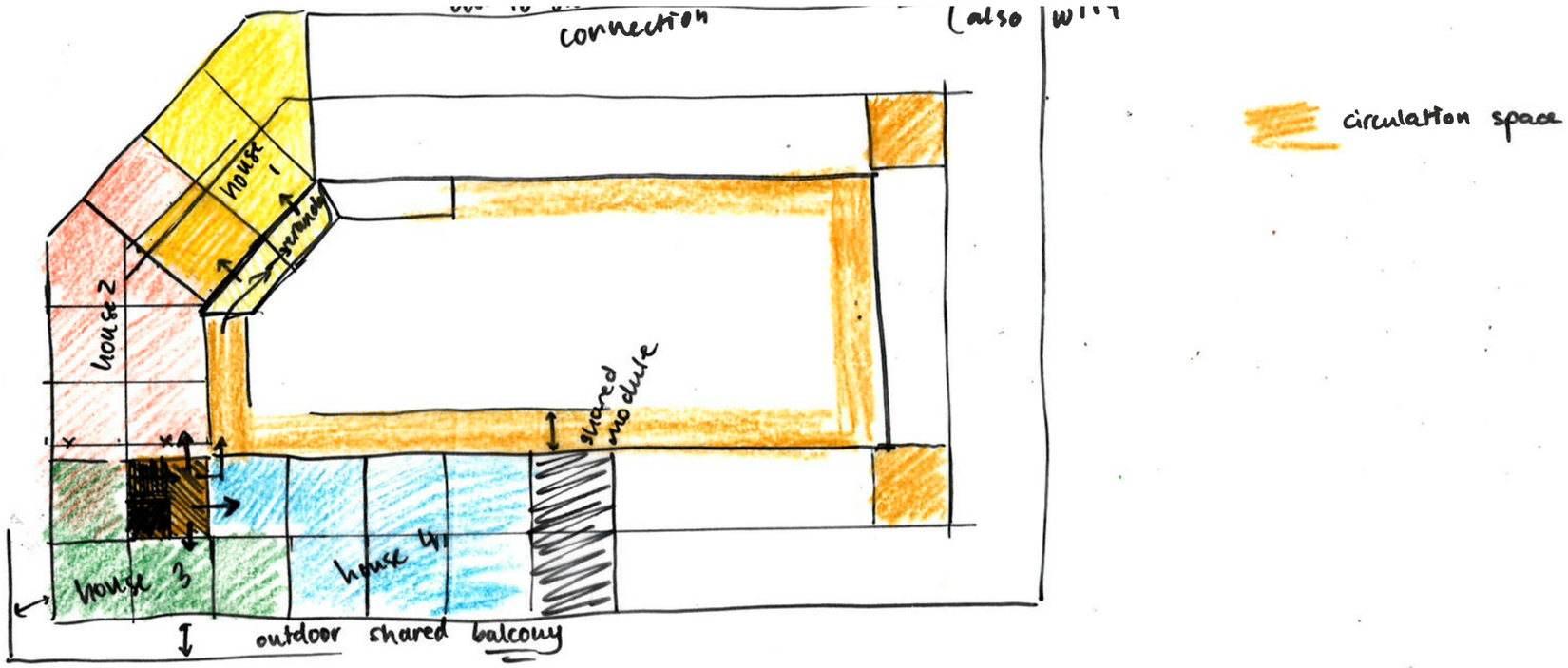
positives

+ circulation very efficient & not within the grid of the housing, therefore easier flexibility in adapting the design
+ little depth in the builiding, so daylight shouldn't be a problem
+ easy to create a buffer zone in front of the front door, due to the gallery being part of the entrance - therefore it's good for desinging with a transition space
+ shared module/space has a defined ownership due to the floors & the staircase attached to the gallery
+ the gallery & central stair cases due stimulate more collectivety and meeting between neighbours

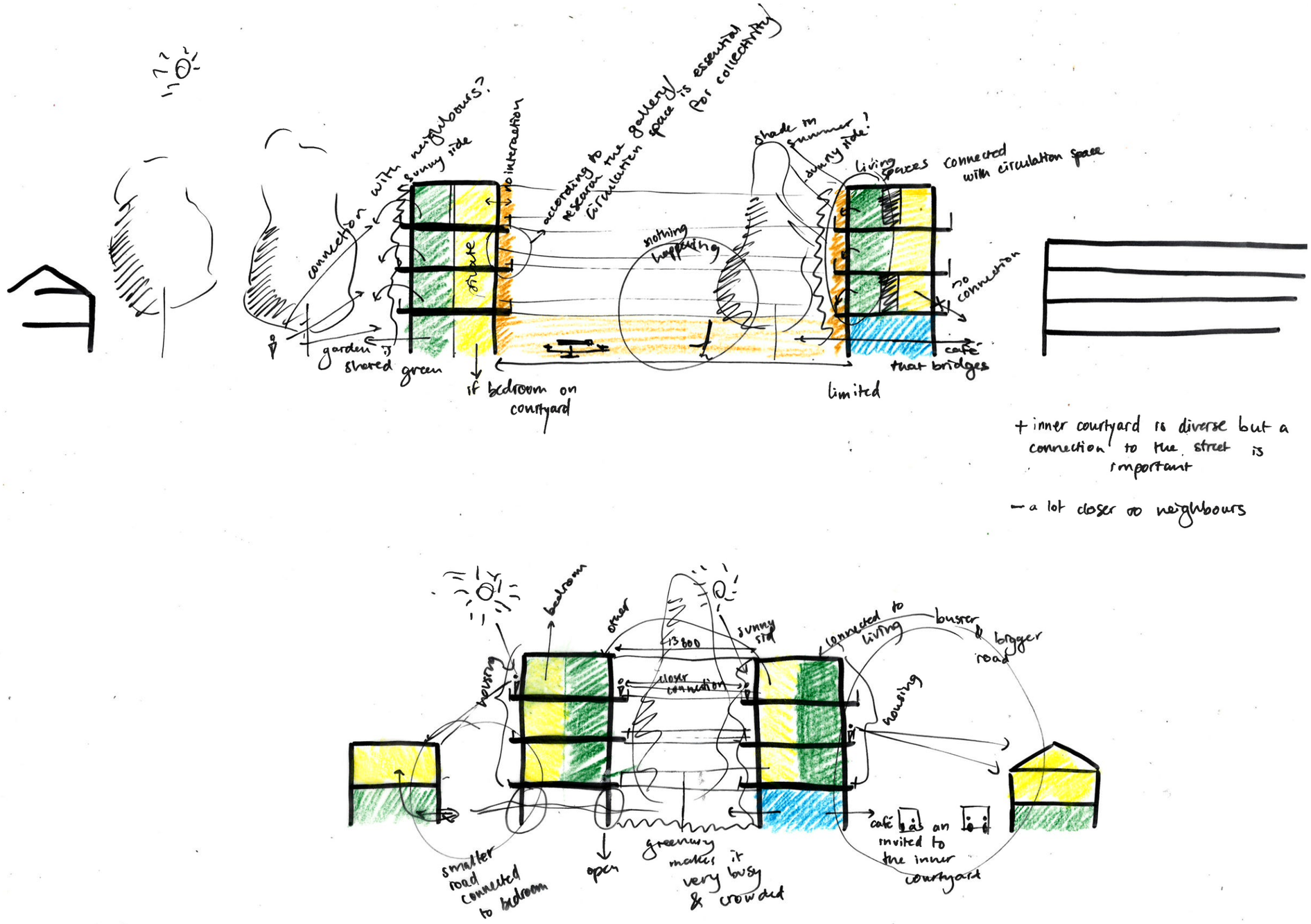
negatives

- there's little happening on the ground floor (if you place homes there), it doesn't stimulate collectiveness on the ground floor or with the neighbours
- the courtyard space is relatively small & not very lively
- the house with an inner courtyard can only be placed on the top floors due to the stacking (can be an issue...)
- the width of the building (within this plot) is about 2 modules which is not very big and might limit the floorplan options
- the plot is slightly small (if the row of house is kept) which makes this typology quite 'squashed' between the existing buildings

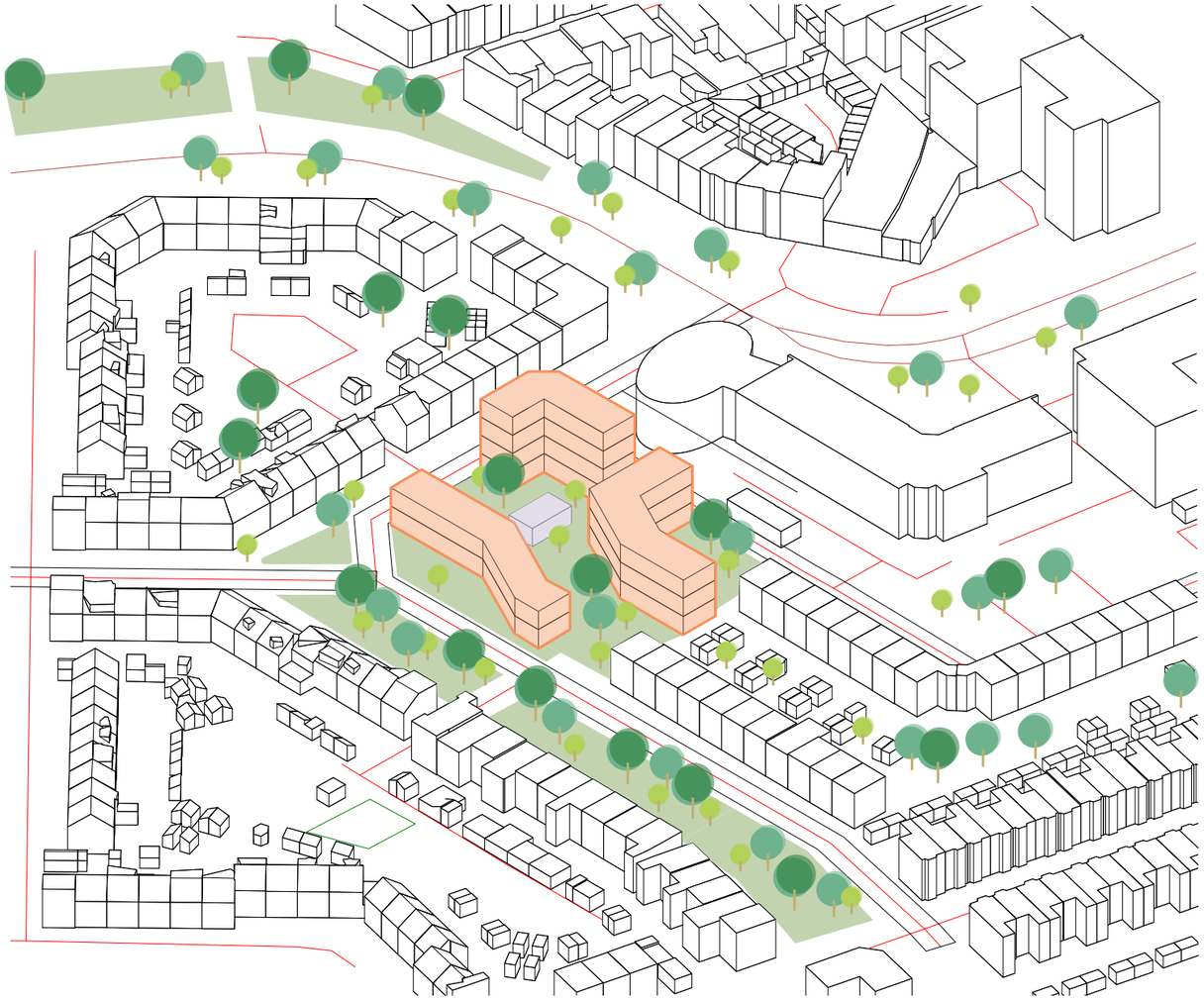
typology b | gallery.



typology b | gallery.



typology c | open courtyard.



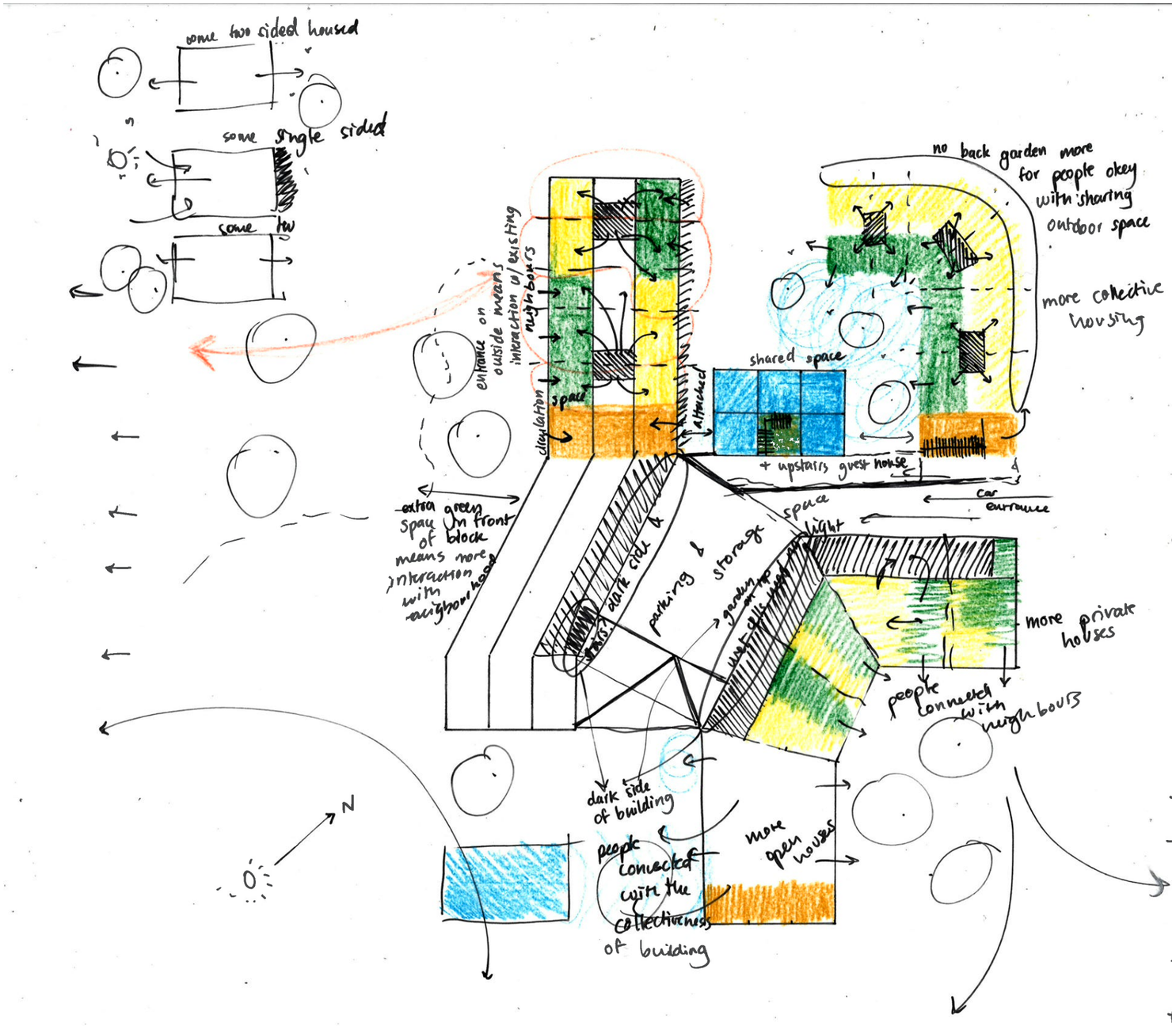
positives

+ degree of collectivety is flexible, due to the different building blocks the way that people share and what they share can be very easily chosen by the residents
+ an elevated garden allows circulation to be placed mostly within the collective garden spaces
+ there's green space between the road and the block which allows for the dubble orientation of the block to feel private on either side
+ better connection with the existing neighbours
+ different types of collective spaces
+ more storage & parking space within the plot

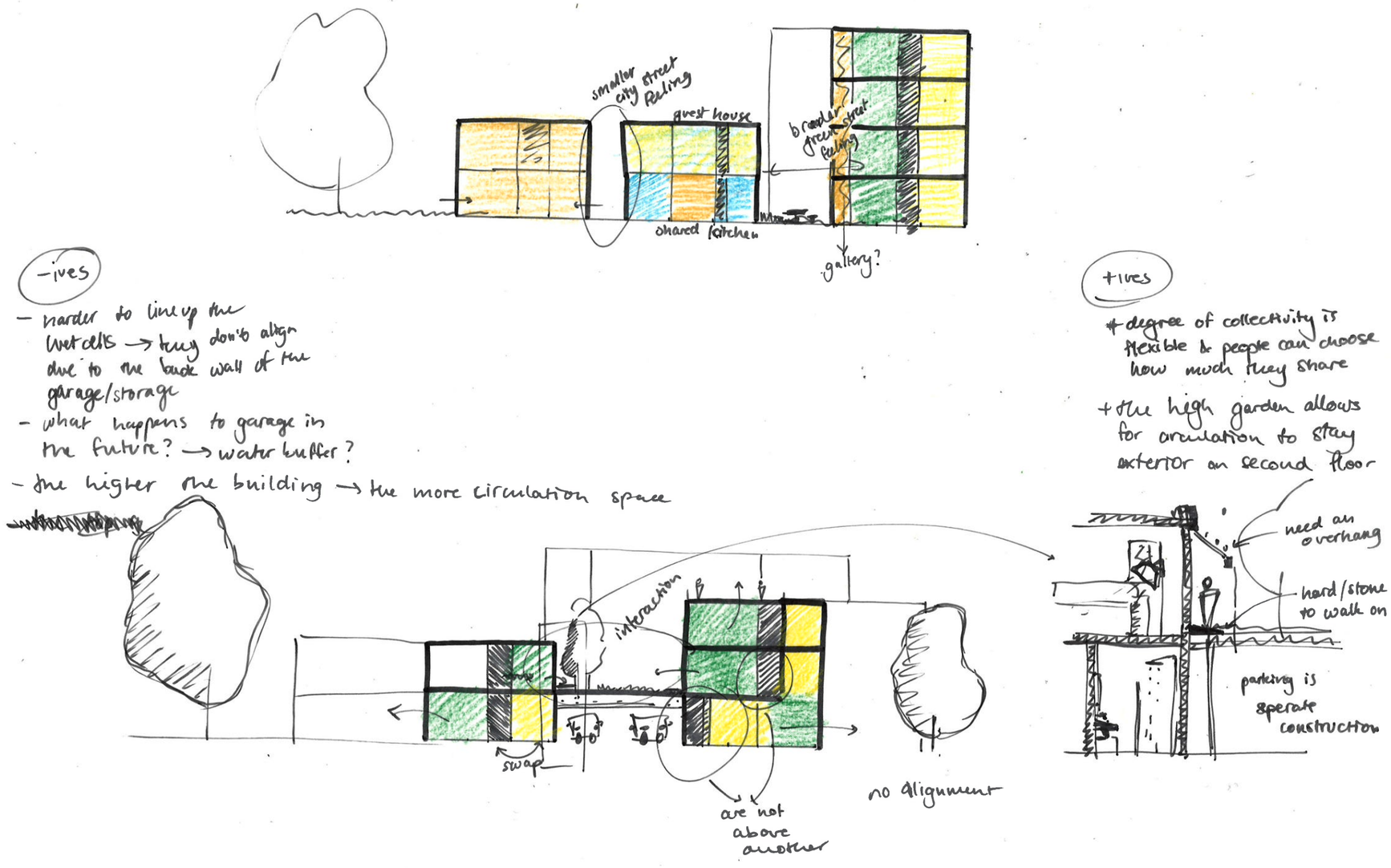
negatives

- the shared space doesn't have too much ownership, which might lead to no one taking care of it
- not all neighbours come in contact with the collective garden due to the entrances being placed on other sides, or the parking
- the parking can limit the orientation of the houses (not extremely flexible)
- within heigher buildings it is still necessary to add circulation space

typology c | open courtyard.



typology c | open courtyard.



typology d | closed courtyard.



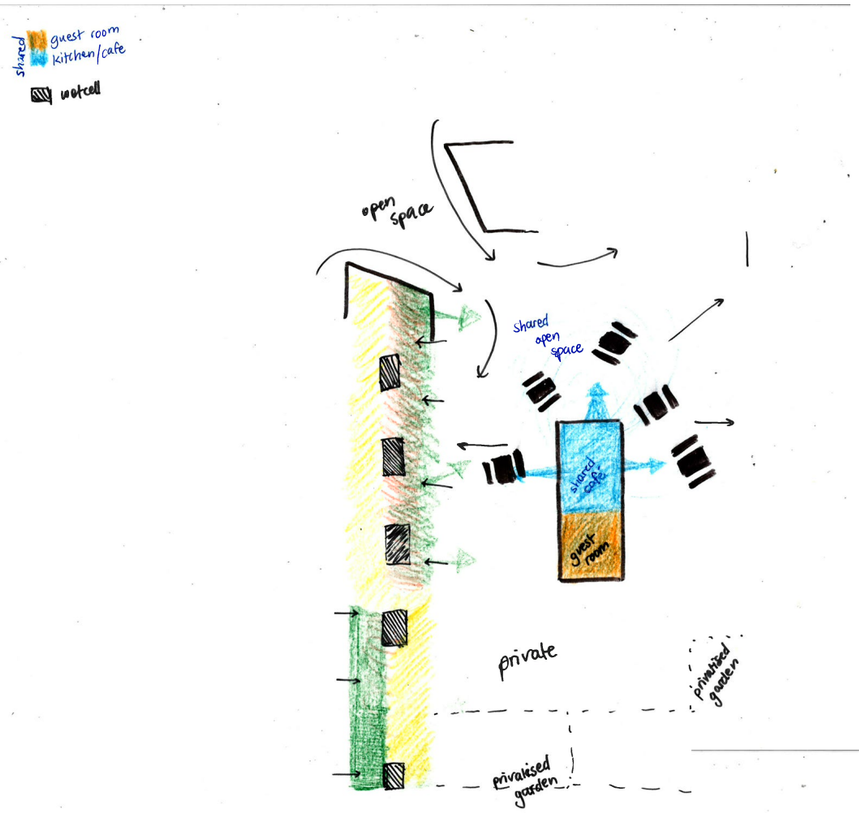
positives

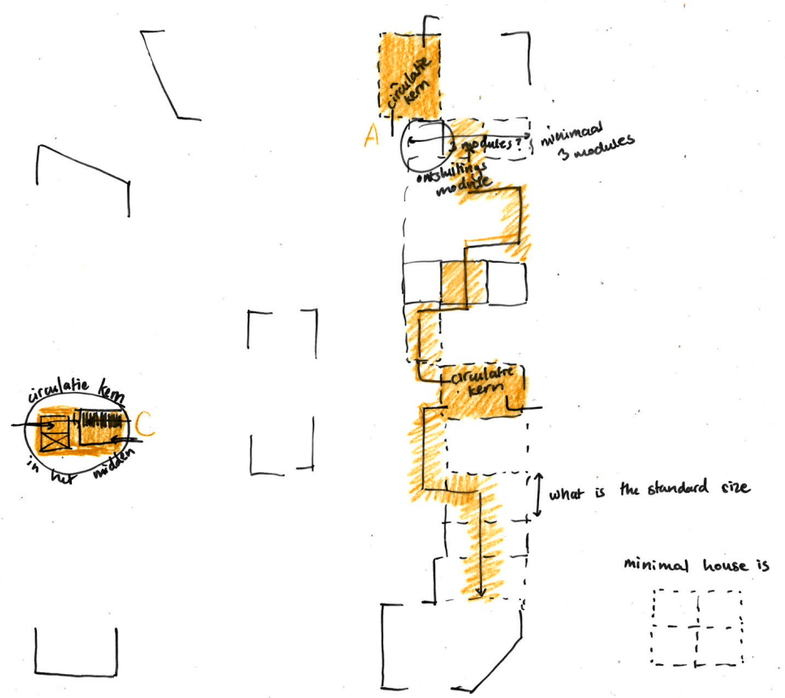
+ diversity in directions of the household (the two-sided orientation of the block allows for easier changes in orientation)
+ the height of the buildings allows for a private feeling within the courtyard & therefore possibly within the homes
+ the shared building in the middle allows for a focus/centre point within the building that is visible for all households
+ collectivity among the (new) neighbours is boosted by having the circulation & the inner courtyard attached to each other
+ opening within the building block makes a clear entrance side for the building as a whole

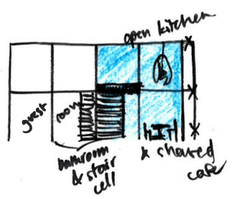
negatives

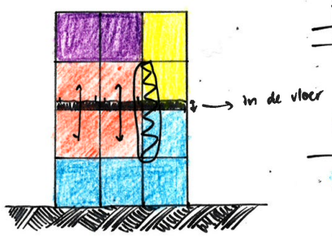
- no real connection with the existing neighbours, a bit of an introverted building
- the homes can be very diverse in their orientation, but will always have a side that is visible to the existing neighbours and one that is visible from the courtyard (so little privacy)
- limited public/collective space, only the collective garden/building in the centre of the building block
- if there's a courtyard home typology, then this is only possible on the top floors, due to the height of the building
- no real space for parking (this needs to be present due to the diversity of people living in the building)

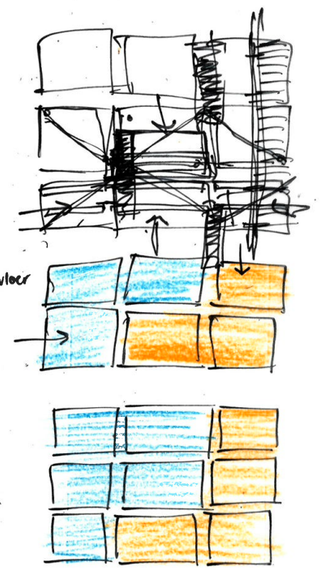
typology d | closed courtyard.



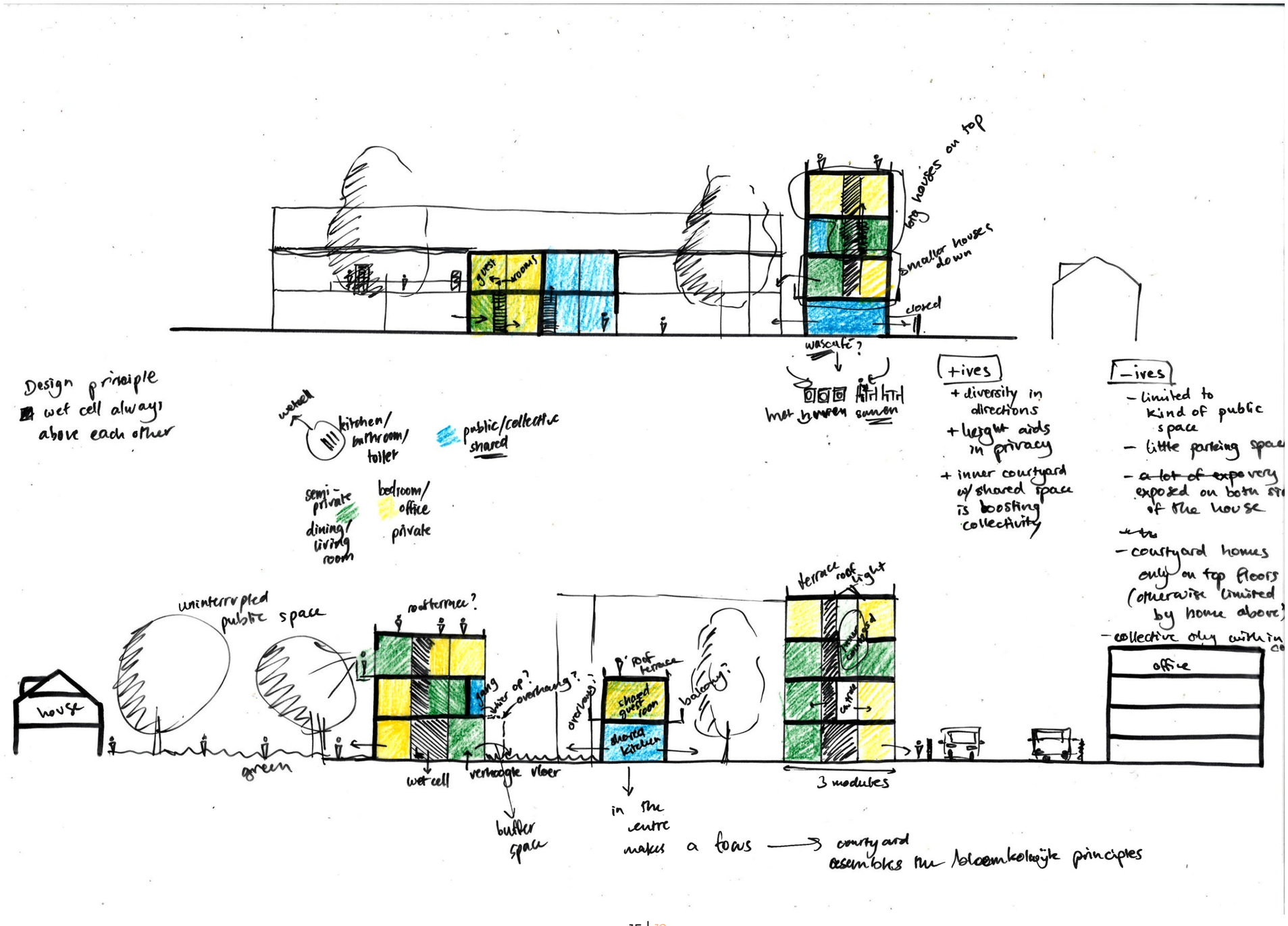








typology d | closed courtyard.



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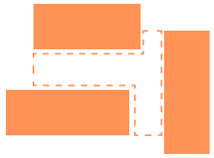
puu-käpylä.



architect.	Marrti Välikangas & Akseli Toivonen
year of completion.	1925
location.	Pohjolankatu, Helsinki, Finland
plot m².	238 000 m²
n° of dwellings.	517
dwellings size.	45-112 m²
co-living typology.	guest house
shared spaces.	sauna's, gardens (with allotment spaces), laundry rooms

design in context.



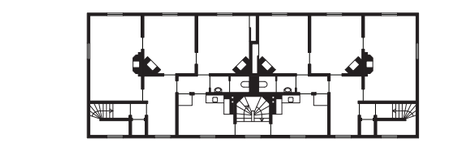
impression images.

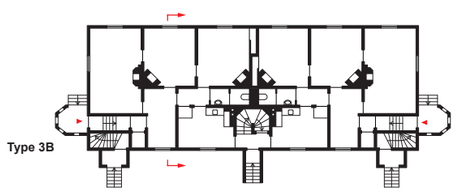




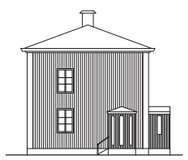


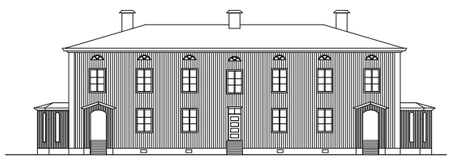

additional drawings.


Eerste etage
First floor

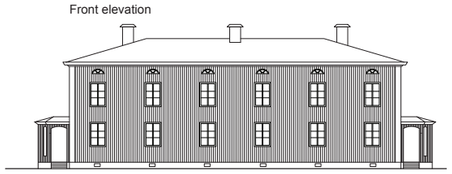

Type 3B

Begane grond
Ground floor


Zijaanzicht
Side elevation

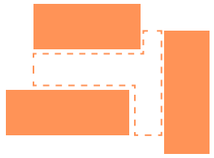

Vooraanzicht
Front elevation


Doorsnede
Section


Achteraanzicht
Rear elevation

0 2 10m

meer&deel.



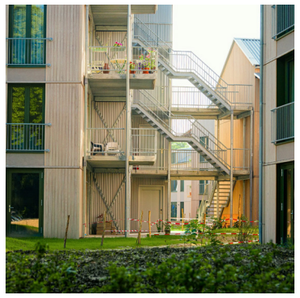
architect.	Atelier to the Bone, Werkstatt Architecten, van Tuijn Stedebouw
year of completion.	2024
location.	Vredeoord, Eindhoven the Netherlands
plot m².	8 155 m²
n° of dwellings.	40
dwellings size.	45-150 m²
co-living typology.	guest house
shared spaces.	shared ownership (cpo), gardens, workspaces, meeting rooms, guest bedrooms

design in context.



impression images.





additional drawings.



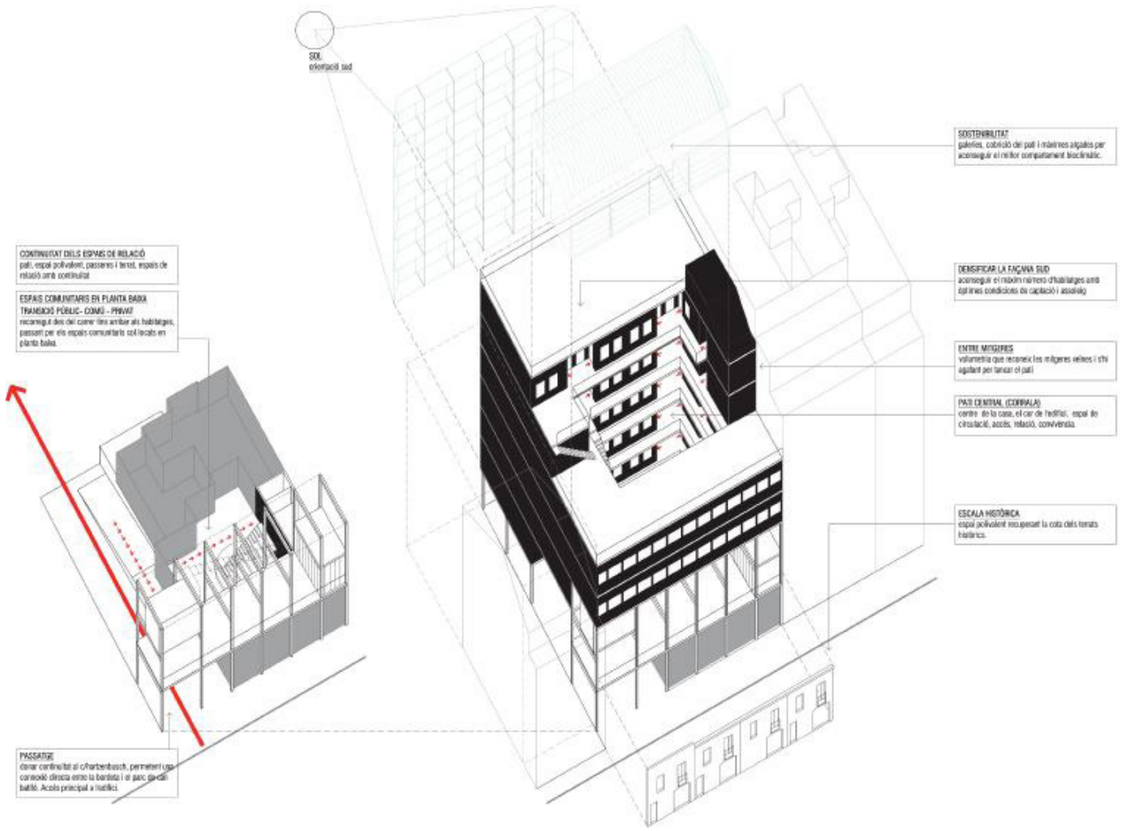
la borda.

architect. lacol.
year of completion. 2018
location. Can Batlló, Barcelona, Spain

plot m². 3 000 m²
n° of dwellings. 28
dwellings size. 40, 60, 75 m²

co-living typology. gallery
shared spaces. inner courtyard, laundry room, kitchen, meeting/work room, multi-purpose room

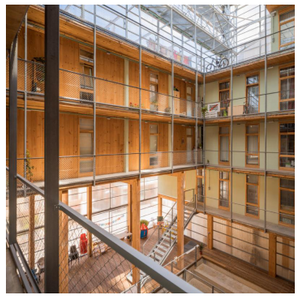
design in context.



impression images.

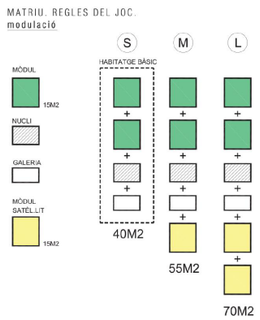


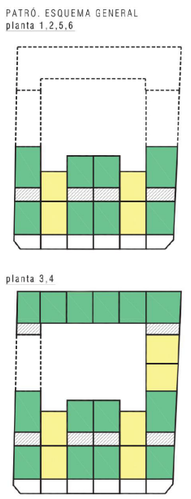





additional drawings.







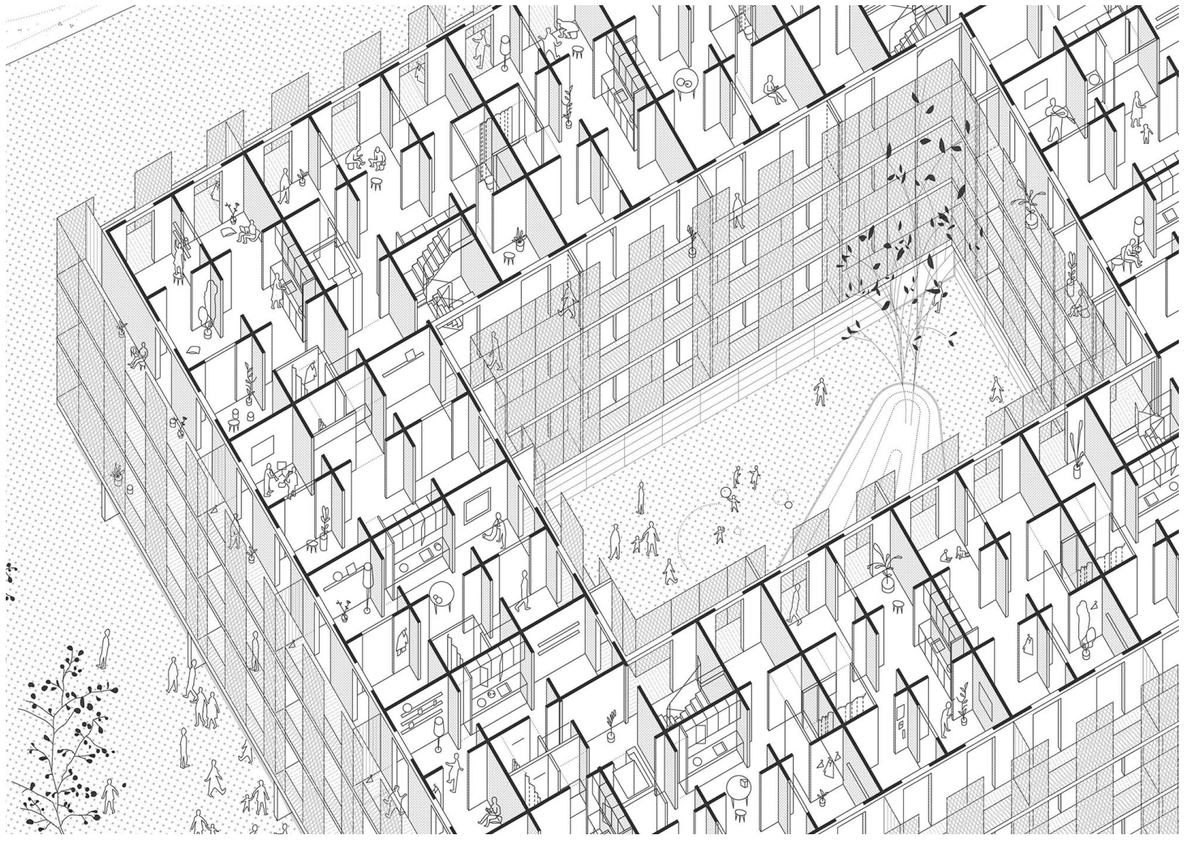
modulus matrix.

architect. Peris+Toral
year of completion. 2020
location. Cornellà de Llobregat, Barcelona, Spain

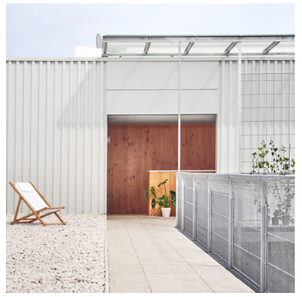
plot m². 2 600 m²
n° of dwellings. 85
dwellings size. 58-78 m²

co-living typology. gallery
shared spaces. inner courtyard, rooftop terrace, gallery (collective) on the outside (not the circulation space)

design in context.



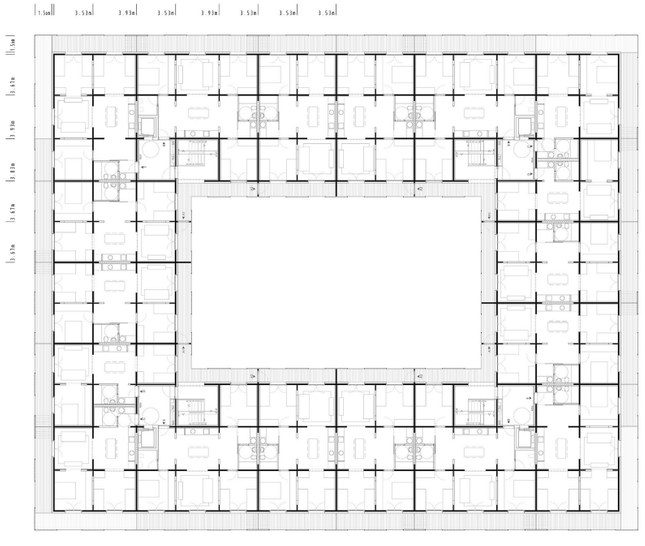
impression images.





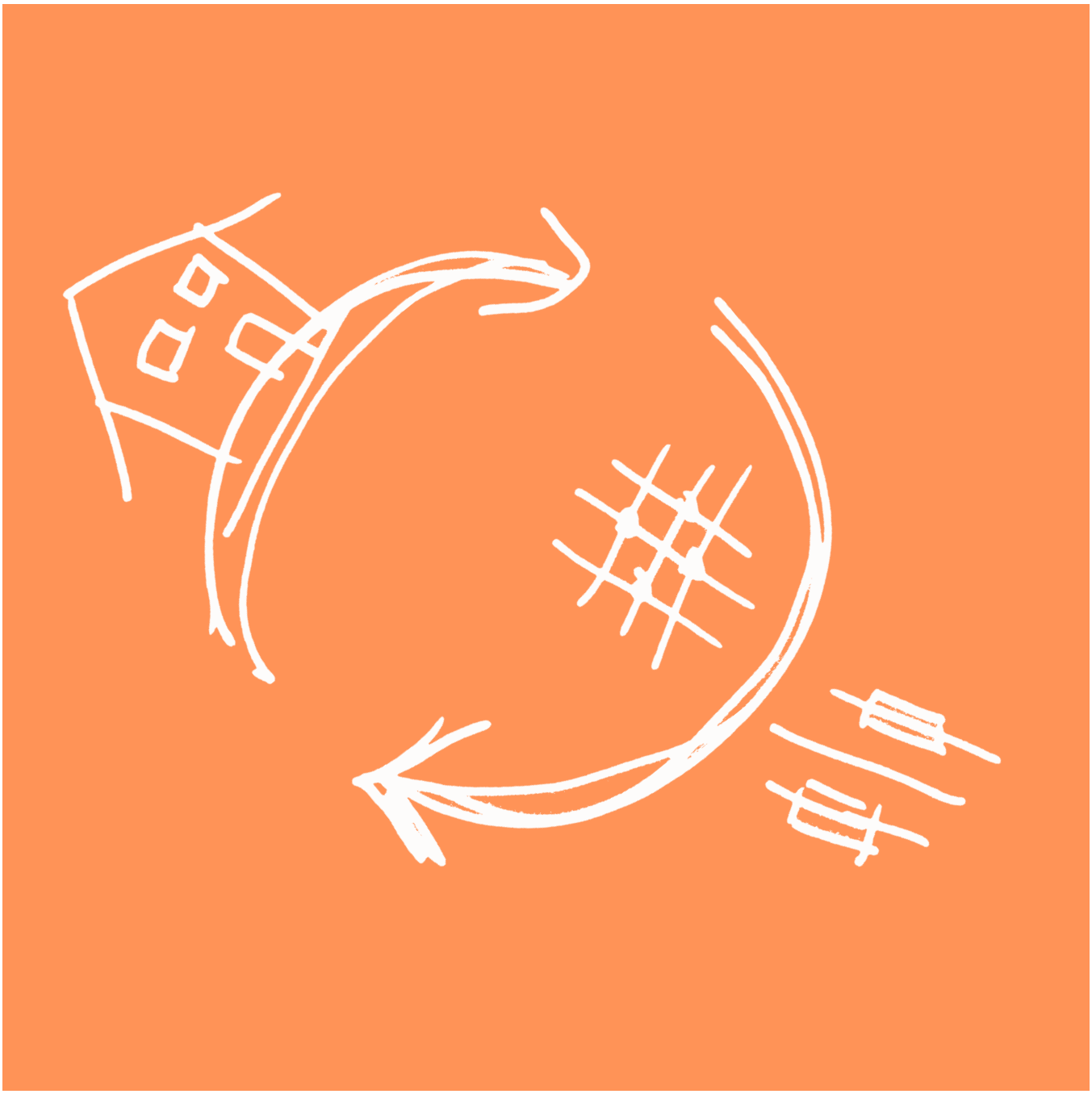
additional drawings.





appendix d.

This appendix is the last gathered booklet for this research. The booklet gathers a series of integral prototyping floorplans. The integration focuses on the combination of both the personas' spatial needs and the adaptive grid system. This booklet defined the final grid system.



synergic studies .

between **open building** analysis & varying **spatial needs.**

april 2026

emma
van barneveld.

tu delft
master thesis.

table of contents.

introduction. [4-5]

type a households. [6-13]
spatial needs.
testing.

type b households. [14-23]
spatial needs.
testing.

type c households. [24-31]
spatial needs.
testing.

type d households. [32-43]
spatial needs.
testing.

type e households. [44-51]
spatial needs.
testing.

conclusion. [52-53]

introduction.

To further support the design's grid size choice, and to understand the adaptability & versatily of this building system, this booklet aims to prototype by integrating the technological lens (the studied adaptive grid system options) and the use(r) lens (the personas described earlier). The personas have been clustered into 5 main household typologies. This is to limit the prototyping to 25 design options, as opposed to 50. This choice has also been made because in some cases the difference is only in the size of the extra room, or whether the kitchen is closed or open. Assuming that this can still be done in hindsight without affecting the general use of the house.

figure 1.0. *Overview of existing 'adaptive building' research & its influence. Author's work.*

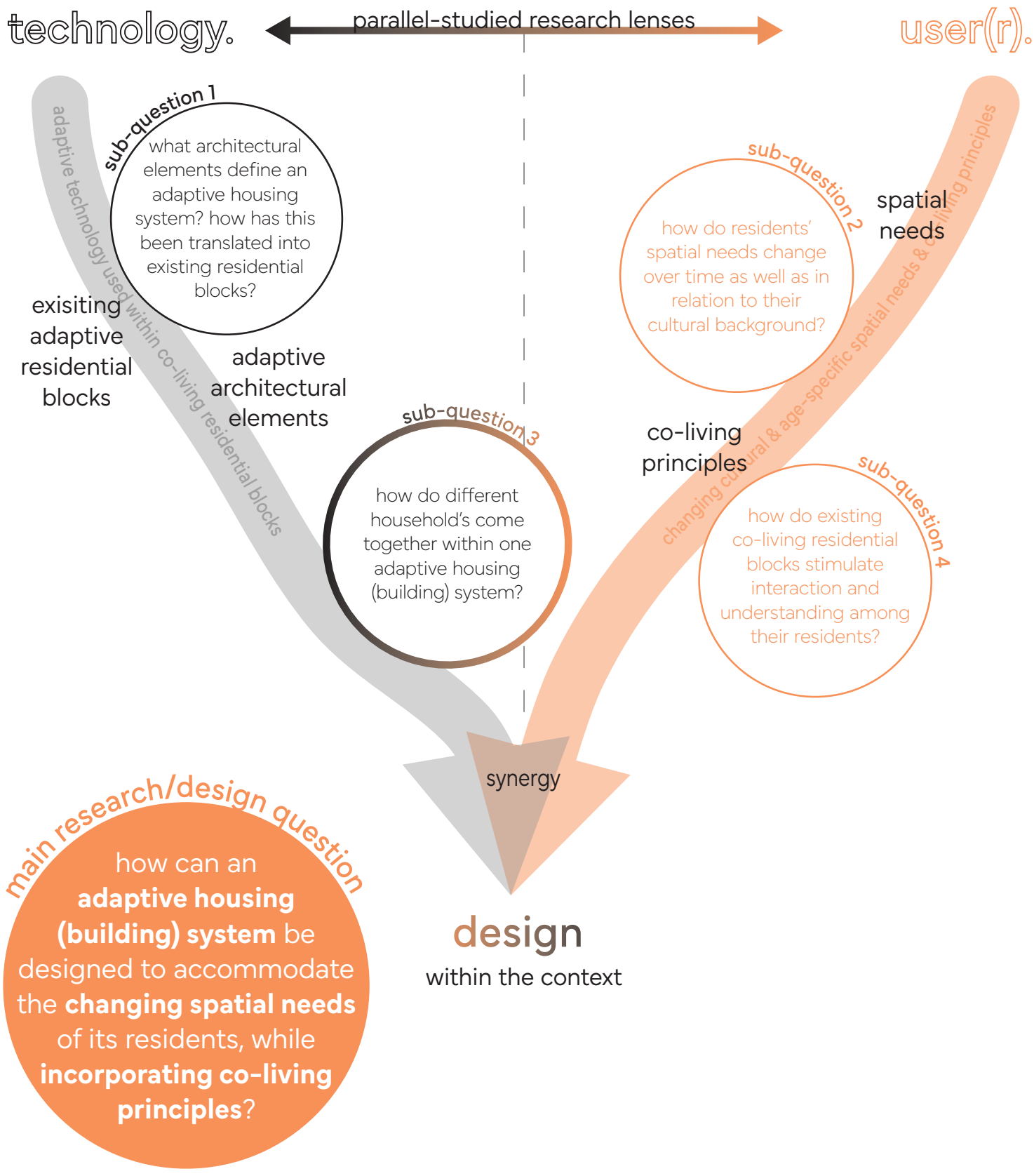

technology.
parallel-studied research lenses
user(r).
sub-question 1
what architectural elements define an adaptive housing system? how has this been translated into existing residential blocks?
exisiting adaptive residential blocks
adaptive technology used within co-living residential blocks
adaptive architectural elements
sub-question 2
how do residents' spatial needs change over time as well as in relation to their cultural background?
spatial needs
changing cultural & age-specific spatial needs & co-living principles
co-living principles
sub-question 3
how do different household's come together within one adaptive housing (building) system?
sub-question 4
how do existing co-living residential blocks stimulate interaction and understanding among their residents?
synergy
main research/design question
how can an **adaptive housing (building) system** be designed to accommodate the **changing spatial needs** of its residents, while **incorporating co-living principles**?
design
within the context

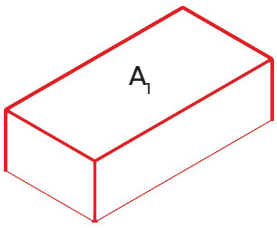
figure 1.0.

type a households.

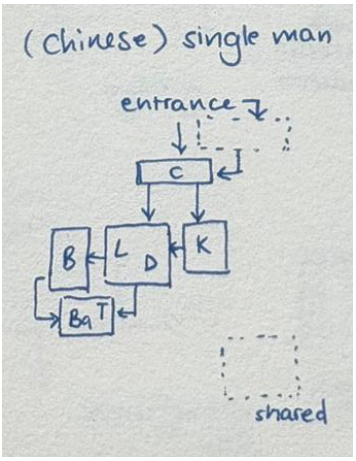
young (chinese) single man.

haitao



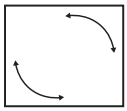


maximum
50m²



bathroom & toilet.

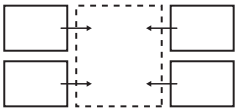
(young) single person



in same space

outside space.

young singles & couples



shared

home office.

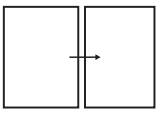
young singles & bigger families



office in the bedroom

bedrooms.

turkish, indonesian & chinese

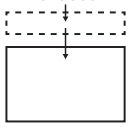


seperate (privacy is important)

entrance.

chinese

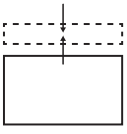
front door



transition in- to outside

outside space.

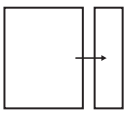
chinese



as a transition space

kitchen.

turkish, chinese & indonesian

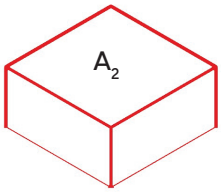


seperate

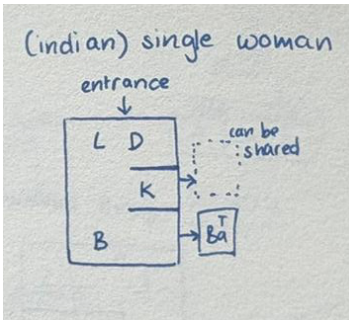
young (indian) single woman.



anaya

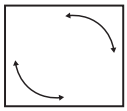


maximum
35m²



bathroom & toilet.

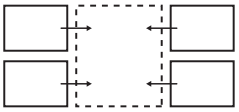
(young) single person



in same space

outside space.

young singles & couples



shared

home office.

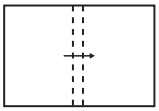
young singles & bigger families



office in the bedroom

bedrooms.

moroccan, indian, dutch, german & polish

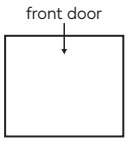


preferably seperate, but studio is accepted when living alone

entrance.

all other cultures

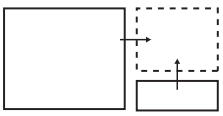
front door



no need for buffer

outside space.

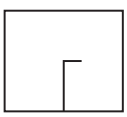
indian, turkish, indonesian, dutch, german & polish



connected to kitchen and/or living (& dining) room

kitchen.

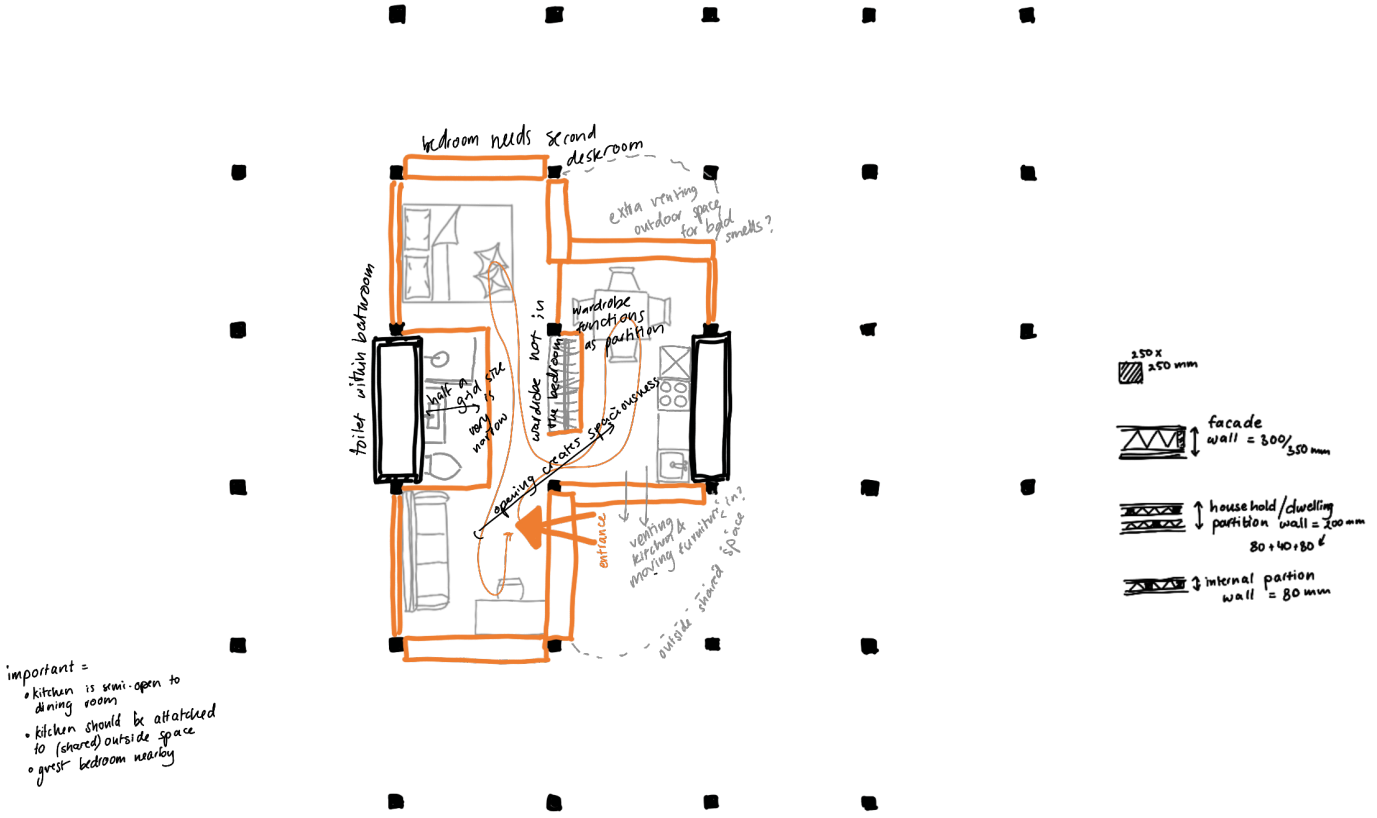
indian & moroccan

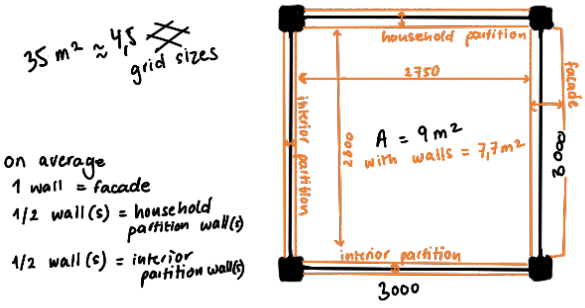


semi-open

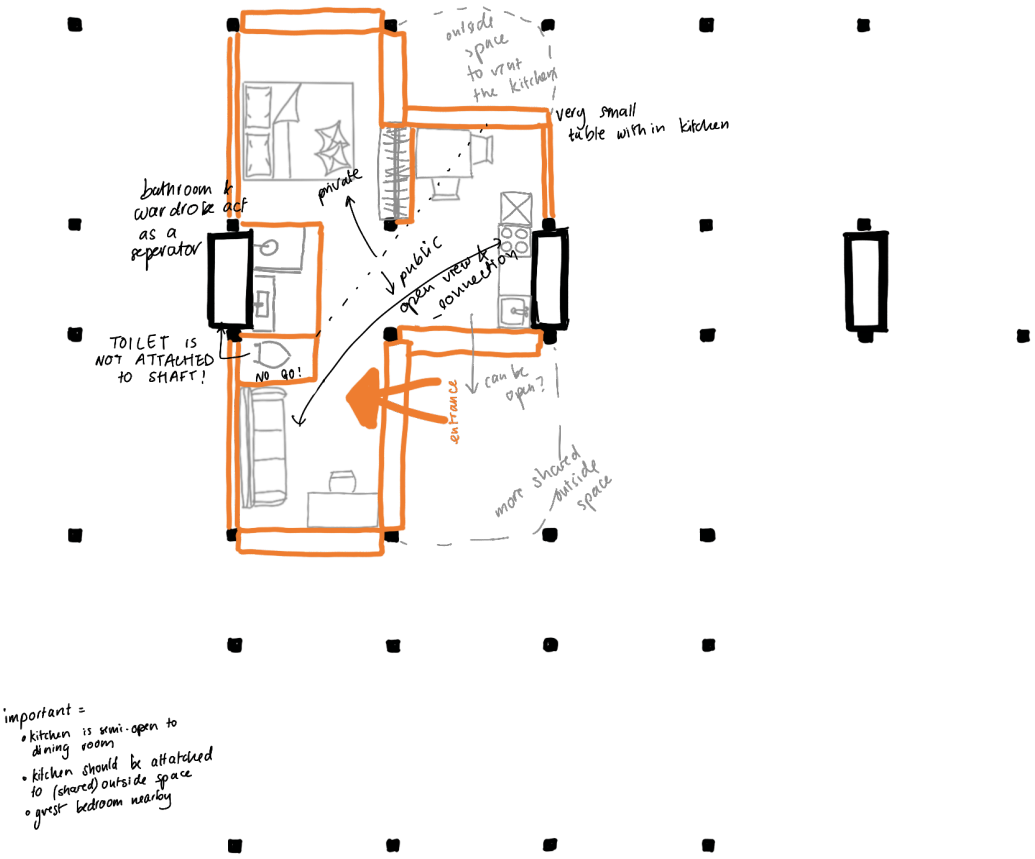
type a household tests.

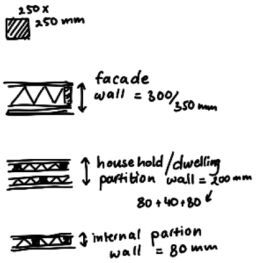
3x3m grid (based on *adaptive co-housing*).



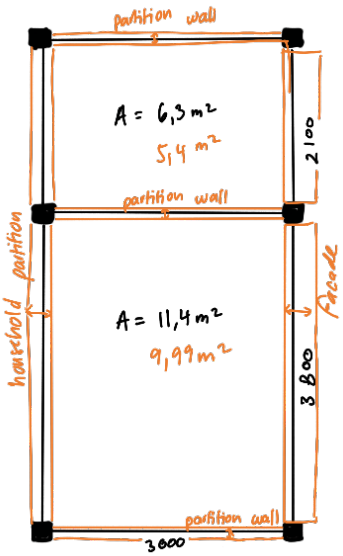


3x3.8m & 3x2.2m grid (based on *quinta monroy*).





important =
- kitchen is semi-open to dining room
- kitchen should be attatched to (shared) outside space
- guest bedroom nearby

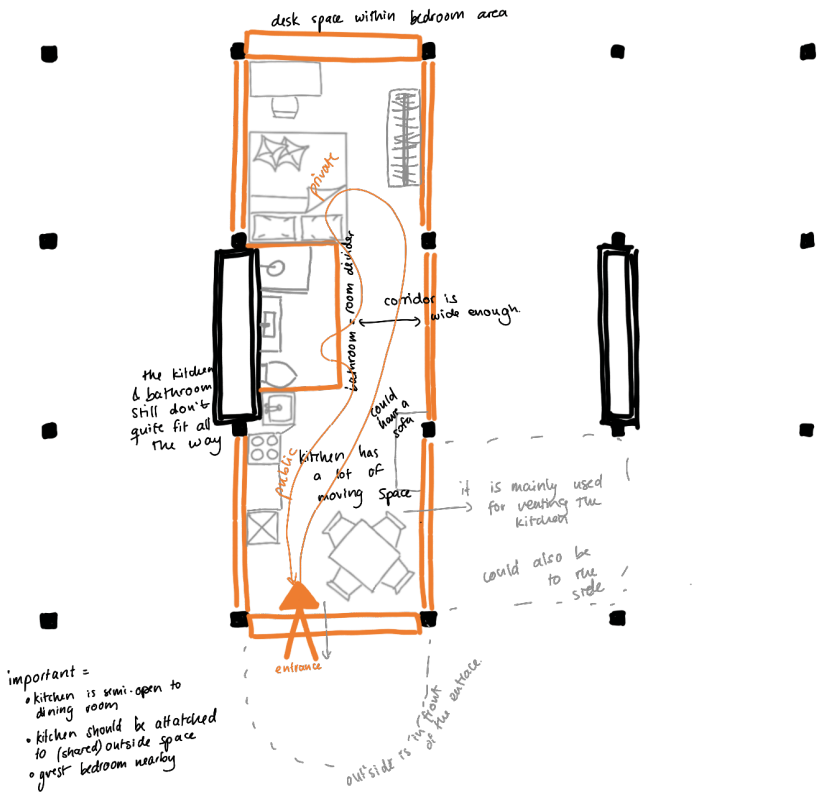


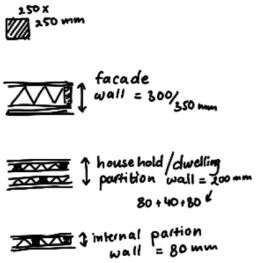
35 m² ≈ 1 small ~~small~~ 3 big ~~big~~ or 2 small ~~small~~ 2,5 big ~~big~~

on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall(s) = interior partition wall(s)

type a household tests (cont.).

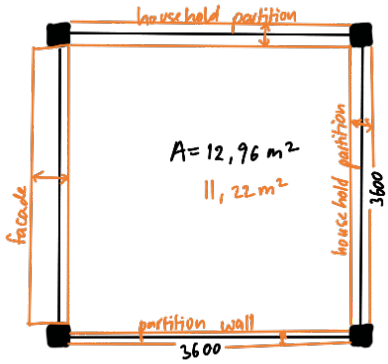
3.6x3.6m grid (based on *laan van de vrede & a simplification of modulus matrix*).



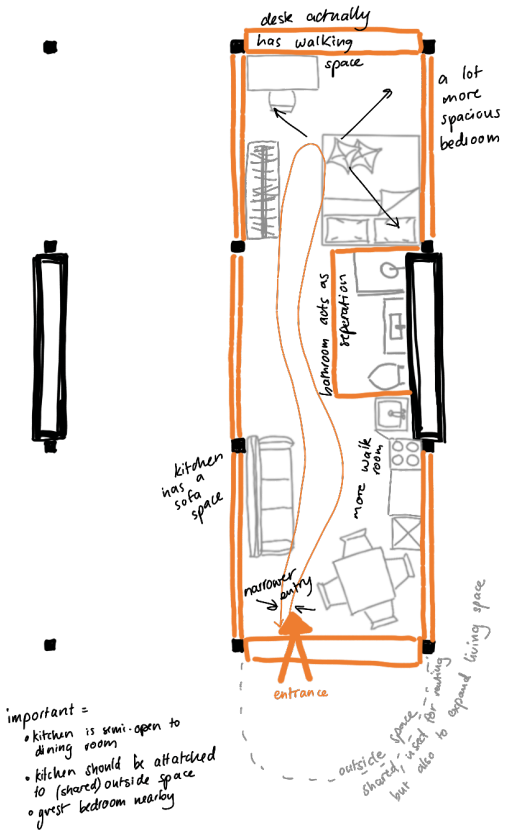


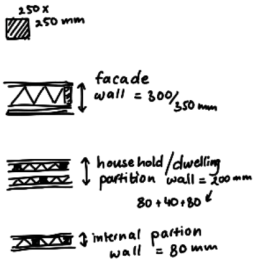
$35m^2 \approx 3$ ~~grid~~ sizes

on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall (s) = interior partition wall(s)



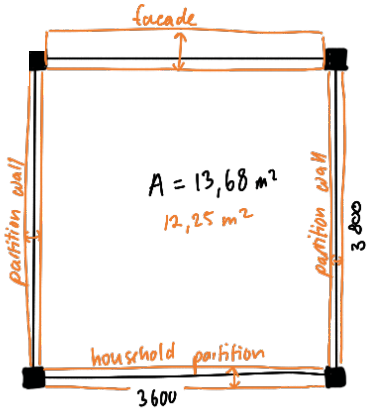
3.6x3.8m grid (based on *san riemo*).





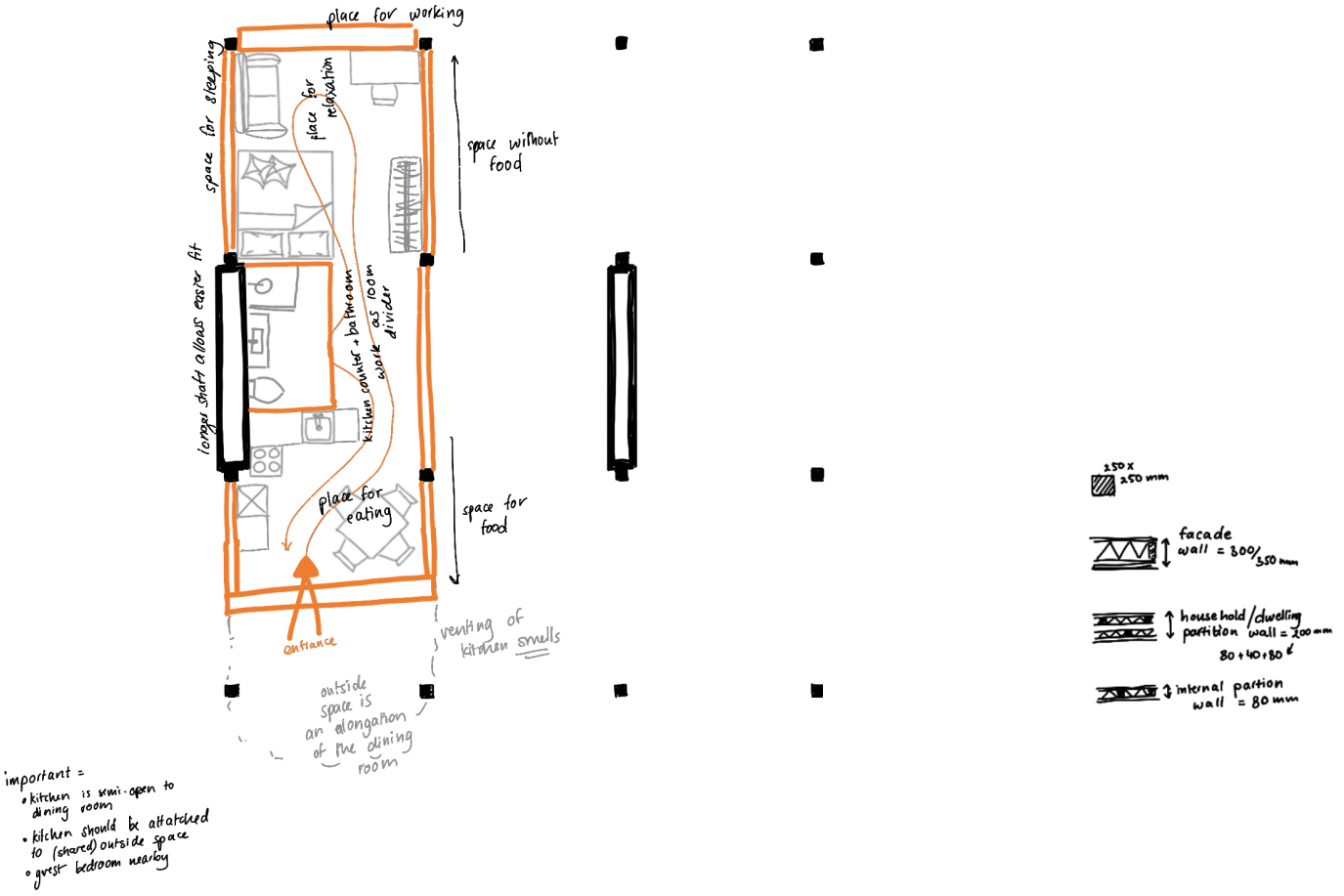
35 m² ≈ 3 ~~grid~~ sizes

on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall(s) = interior partition wall(s)



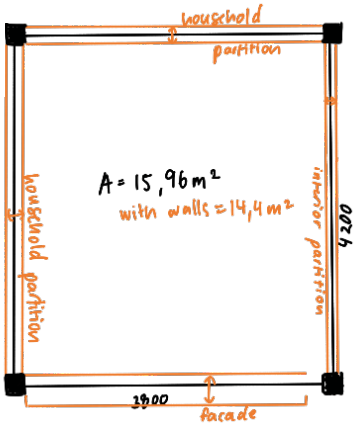
type a household tests (cont.).

3.8x4.2m grid (based on *la borda*).



35 m² ≈ 2,5 ~~#~~ grid size

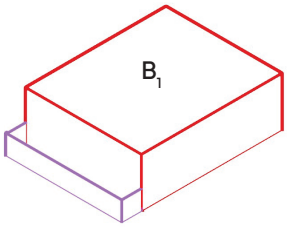
on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall (s) = interior partition wall(s)



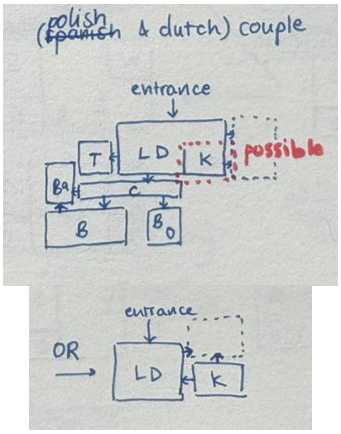
type b households.

young (dutch & polish) couple.



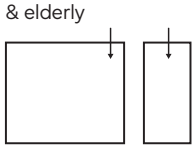


maximum
75m²



bathroom & toilet.

couples, shared housing, families & elderly

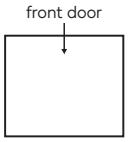


seperate

entrance.

all other cultures

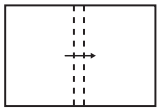
front door



no need for buffer

bedrooms.

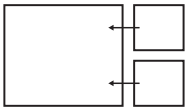
moroccan, indian, dutch, german & polish



preferably seperate, but studio is accepted when living alone

home office.

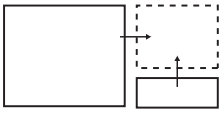
young couples & small families



office (or baby room) seperate from bedroom

outside space.

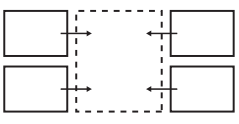
indian, turkish, indonesian, dutch, german & polish



connected to kitchen and/or living (& dining) room

outside space.

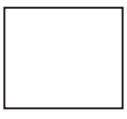
young singles & couples



shared

kitchen.

dutch, german & polish

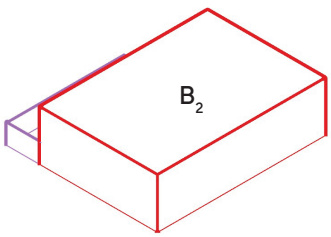


open

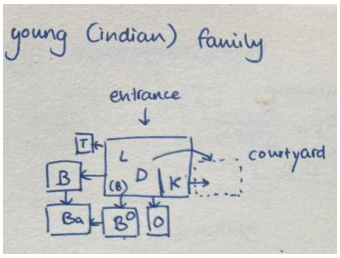
young (indian) family.



young child

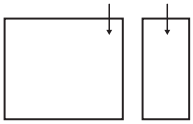


maximum
80m²



bathroom & toilet.

couples, shared housing, families & elderly

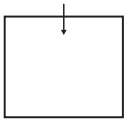


seperate

entrance.

all other cultures

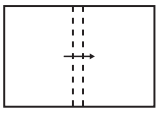
front door



no need for buffer

bedrooms.

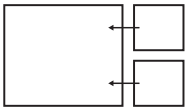
moroccan, indian, dutch, german & polish



preferably seperate, but studio is accepted when living alone

home office.

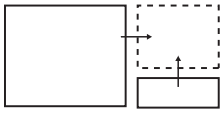
young couples & small families



office (or baby room) seperate from bedroom

outside space.

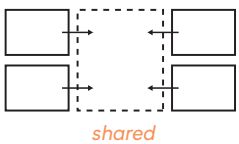
indian, turkish, indonesian, dutch, german & polish



connected to kitchen and/or living (& dining) room

outside space.

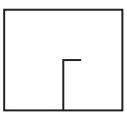
young singles & couples



shared

kitchen.

indian & moroccan



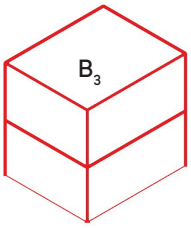
semi-open

type b households (cont.).

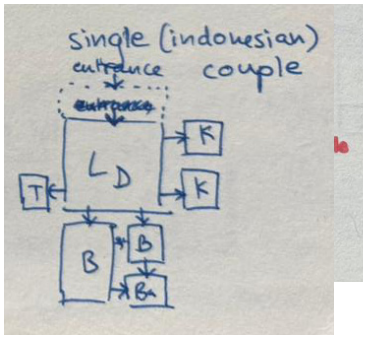
single (indonesian) elderly woman.



erita

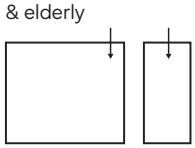


maximum
80m²



bathroom & toilet.

couples, shared housing, families & elderly

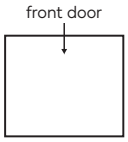


seperate

entrance.

all other cultures

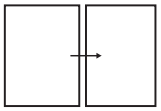
front door



no need for buffer

bedrooms.

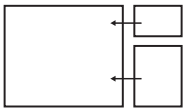
turkish, indonesian & chinese



seperate (privacy is important)

home office.

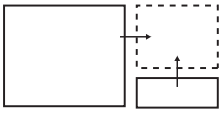
elderly



no office, but guest bedroom

outside space.

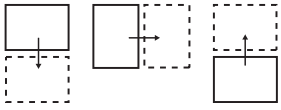
indian, turkish, indonesian, dutch, german & polish



connected to kitchen and/or living (& dining) room

outside space.

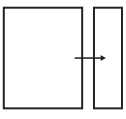
families & older couples/singles



private

kitchen.

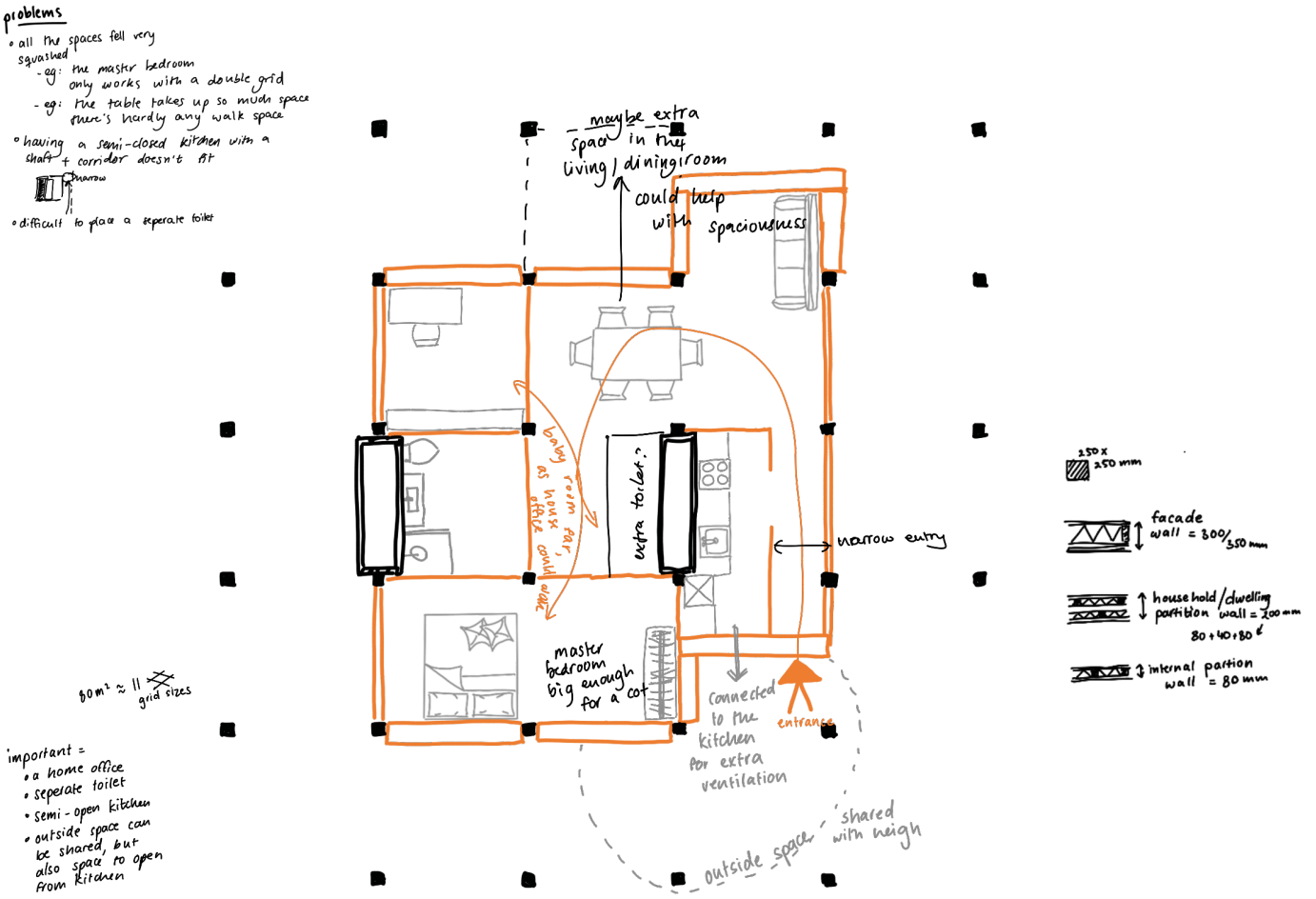
turkish, chinese & indonesian

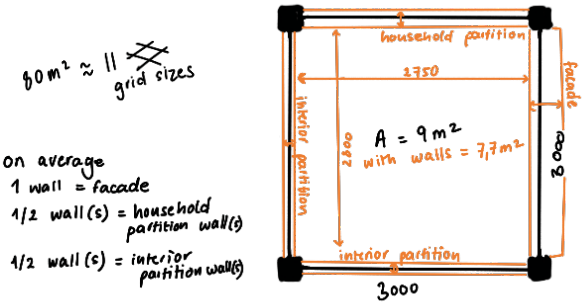


seperate

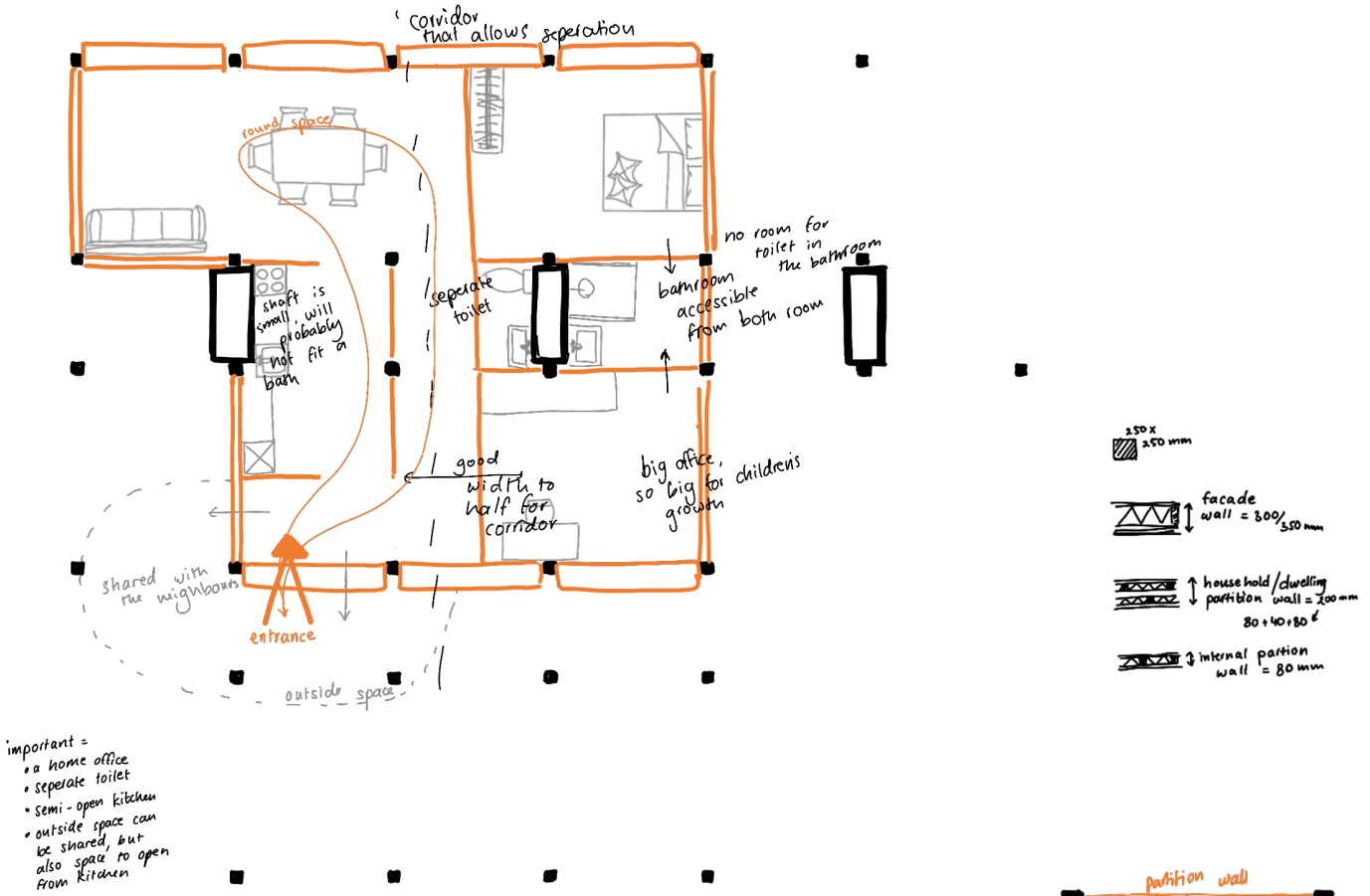
type b household tests.

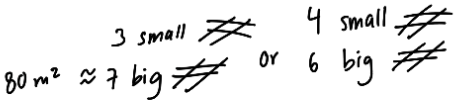
3x3m grid (based on *adaptive co-housing*).



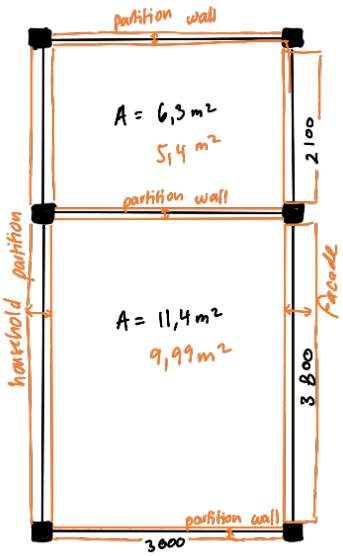


3x3.8m & 3x2.2m grid (based on *quinta monroy*).



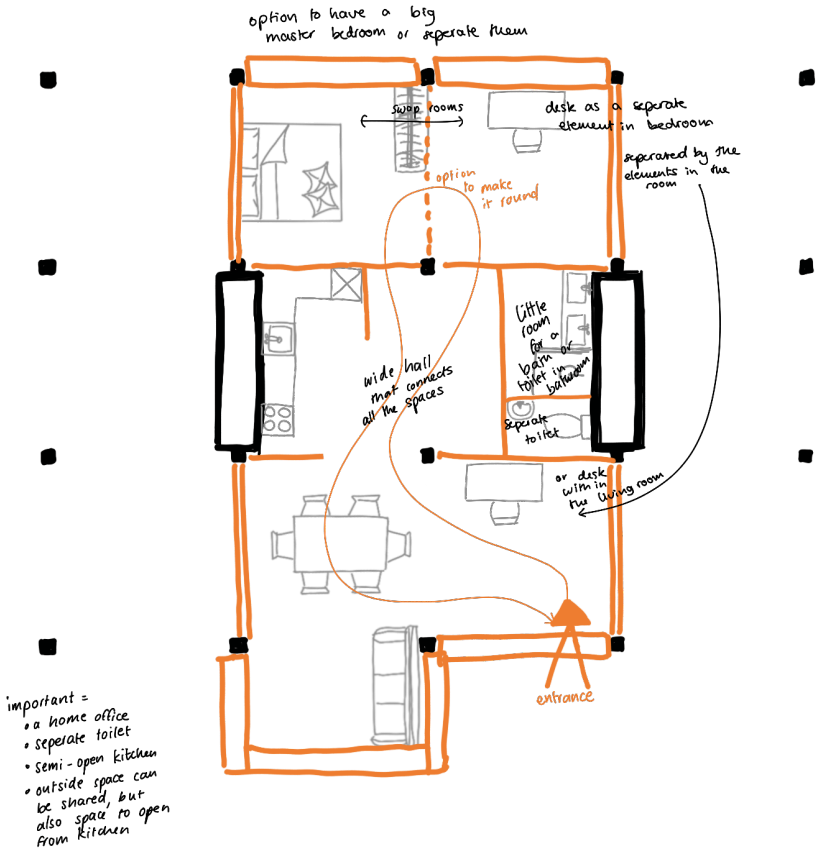


on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall(s) = interior partition wall(s)

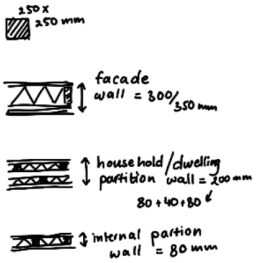


type b household tests (cont.).

3.6x3.6m grid (based on *laan van de vrede & a simplification of modulus matrix*).

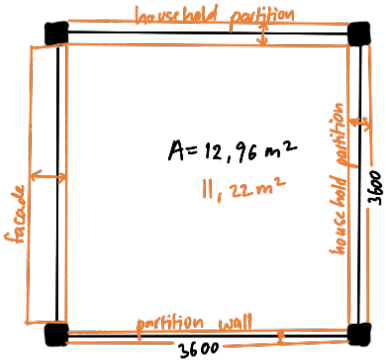


important =
- a home office
- seperate toilet
- semi-open kitchen
- outside space can be shared, but also space to open from kitchen

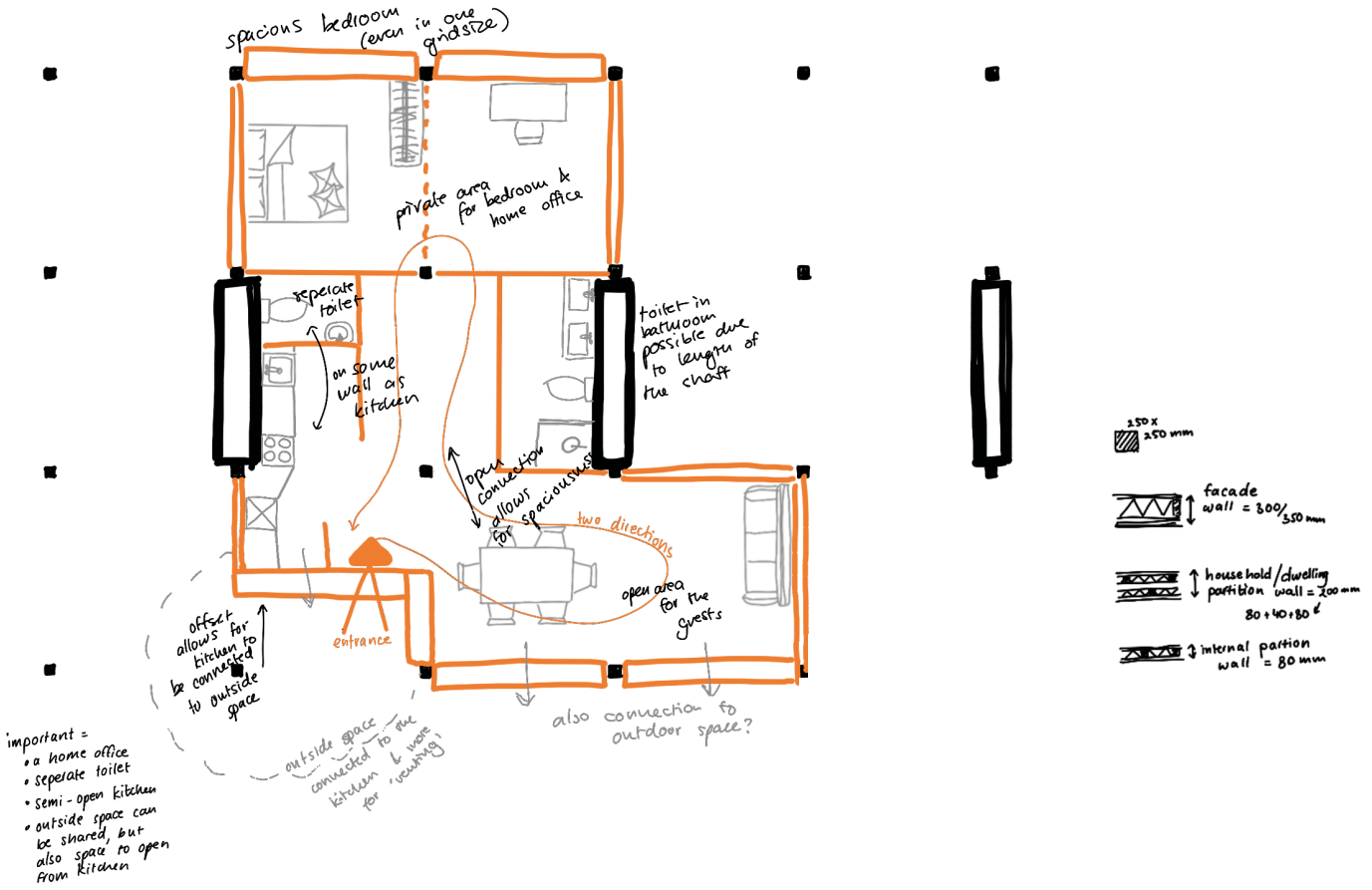


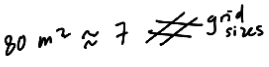
$80\ m^2 \approx 7$ ~~grid~~ sizes

on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall (s) = interior partition wall(s)

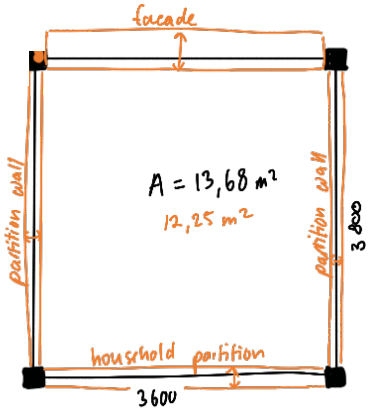


3.6x3.8m grid (based on *san riemo*).



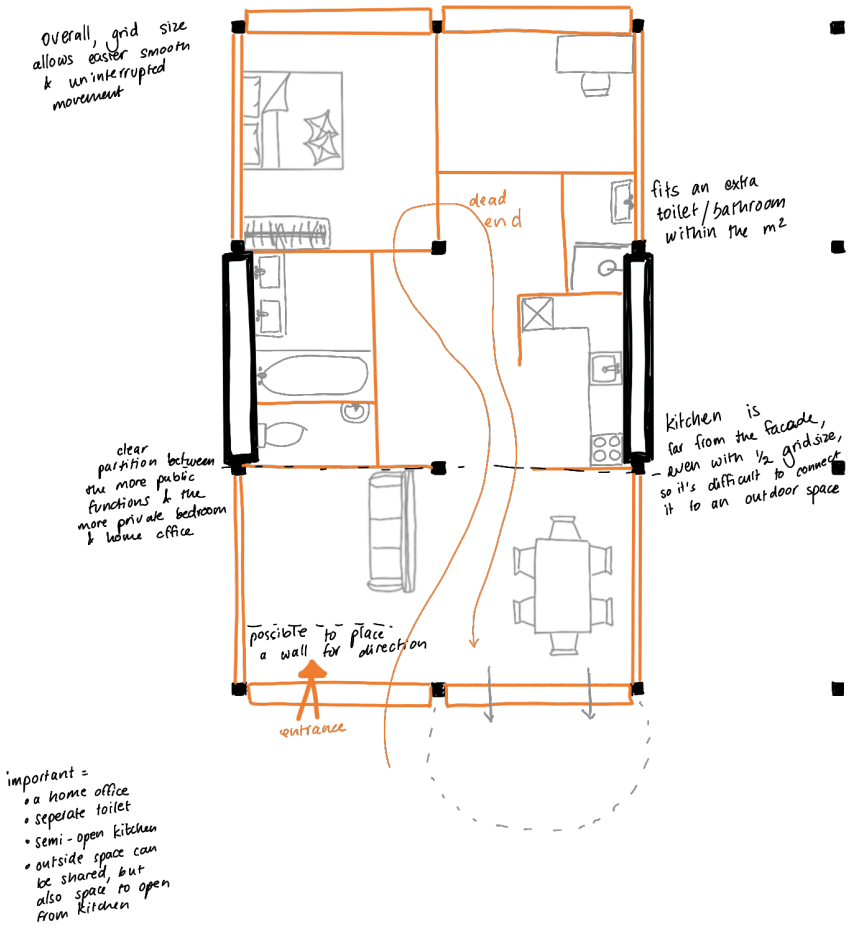


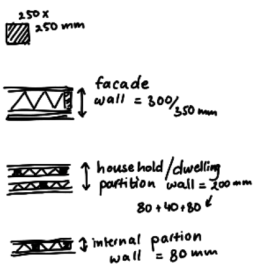
on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall(s) = interior partition wall(s)



type b household tests (cont.).

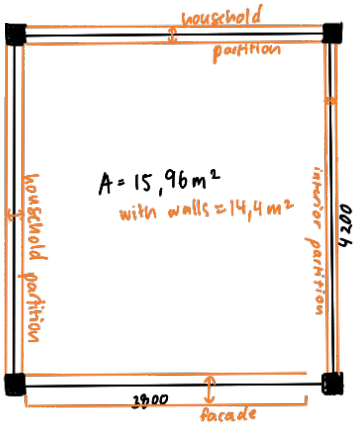
3.8x4.2m grid (based on *la borda*).





$80\ m^2 \approx 6$ ~~grid size~~

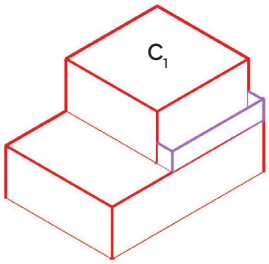
on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall(s) = interior partition wall(s)



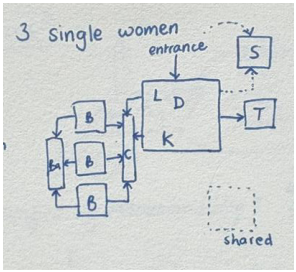
type c households.

3 single (women) young professionals.



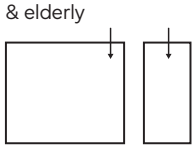


maximum
100m²



bathroom & toilet.

couples, shared housing, families & elderly

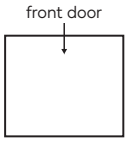


seperate

entrance.

all other cultures

front door

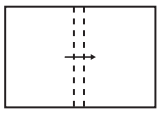


no need for buffer

bedrooms.

3 similar sized bedrooms

moroccan, indian, dutch, german & polish



preferably seperate, but studio is accepted when living alone

home office.

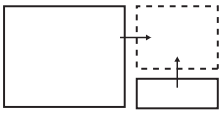
young singles & bigger families



office in the bedroom

outside space.

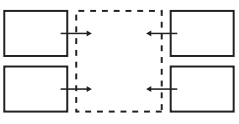
indian, turkish, indonesian, dutch, german & polish



connected to kitchen and/or living (& dining) room

outside space.

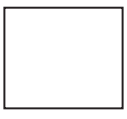
young singles & couples



shared

kitchen.

dutch, german & polish



open

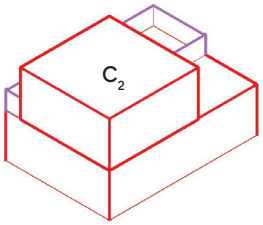
small (turkish) family.

elif's mother

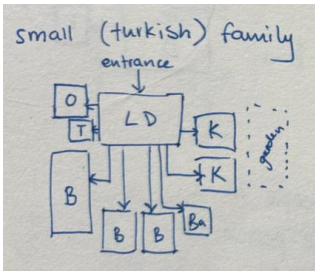




two children

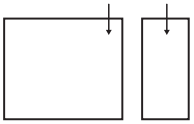


maximum
100m²



bathroom & toilet.

couples, shared housing, families & elderly

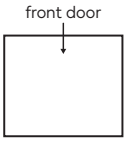


seperate

entrance.

all other cultures

front door

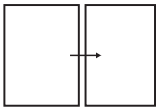


no need for buffer

bedrooms.

at least 1 master bedroom (w/ ensuite bathroom)
2 children/grandparent room

turkish, indonesian & chinese



seperate (privacy is important)

home office.

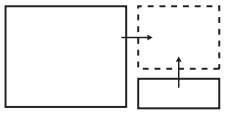
young singles & bigger families



office in the bedroom

outside space.

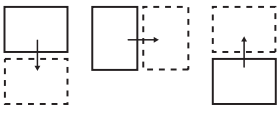
indian, turkish, indonesian, dutch, german & polish



connected to kitchen and/or living (& dining) room

outside space.

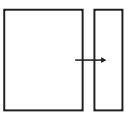
families & older couples/singles



private

kitchen.

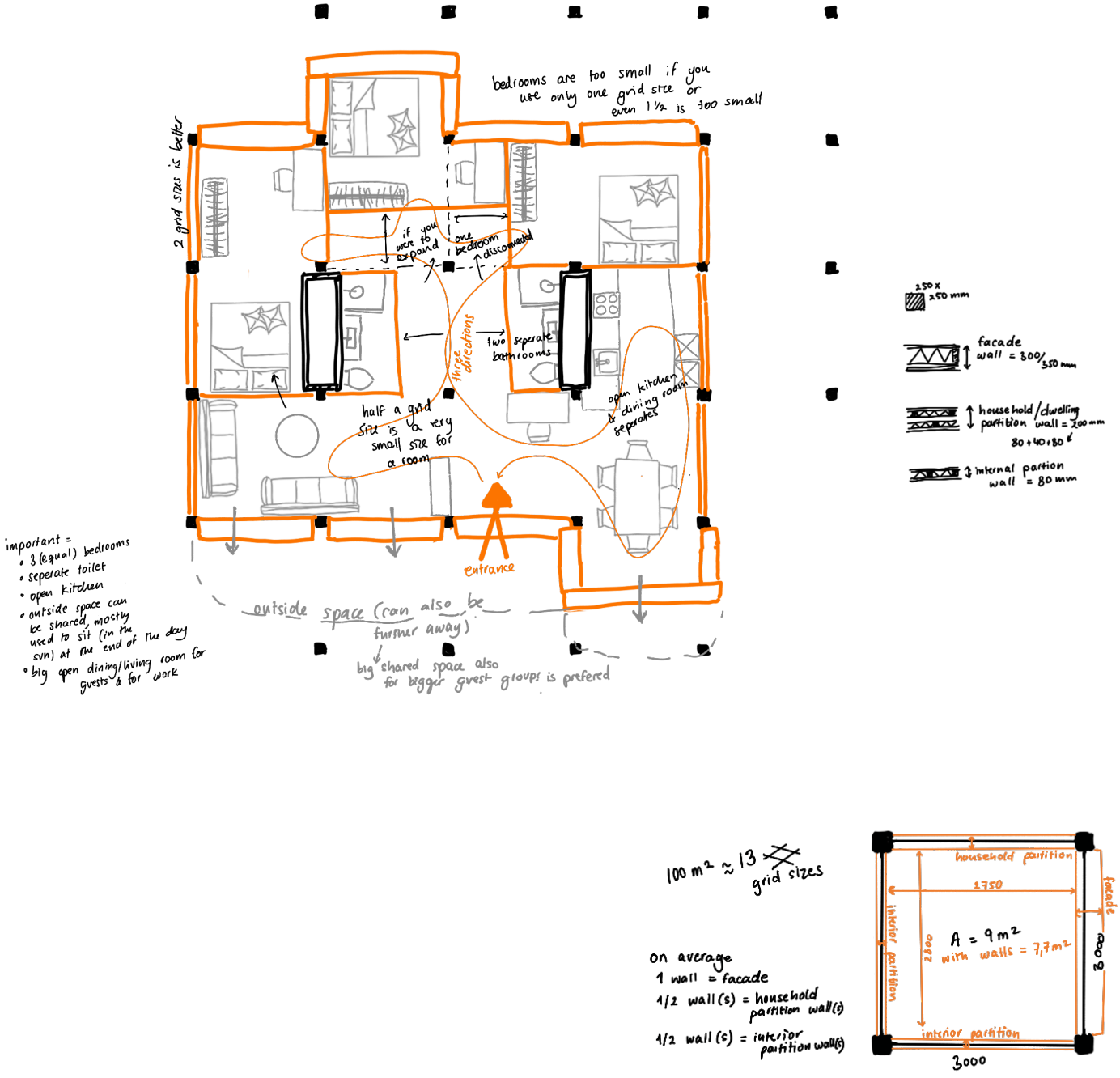
turkish, chinese & indonesian



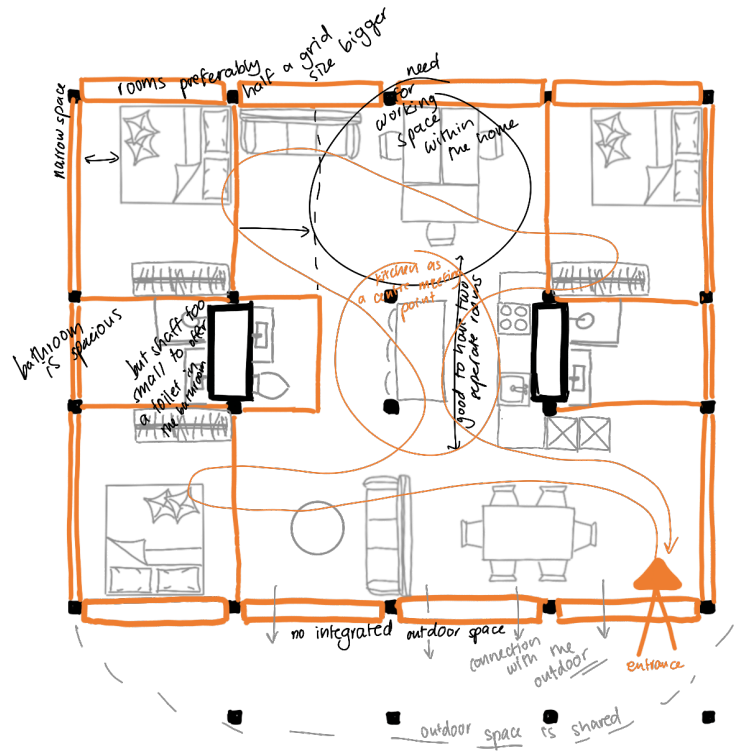
seperate

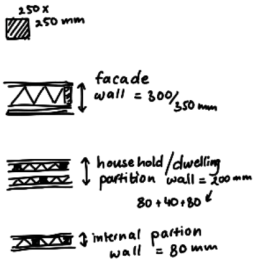
type c household tests.

3x3m grid (based on *adaptive co-housing*).

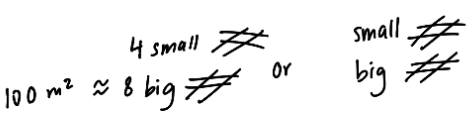


3x3.8m & 3x2.2m grid (based on *quinta monroy*).

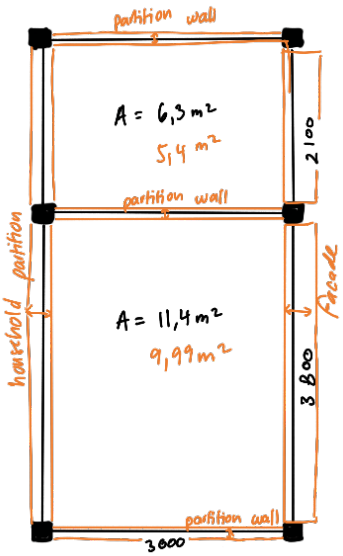




important =
- 3 (equal) bedrooms
- seperate toilet
- open kitchen
- outside space can be shared, mostly used to sit (in the sun) at the end of the day
- big open dining/living room for guests & for work

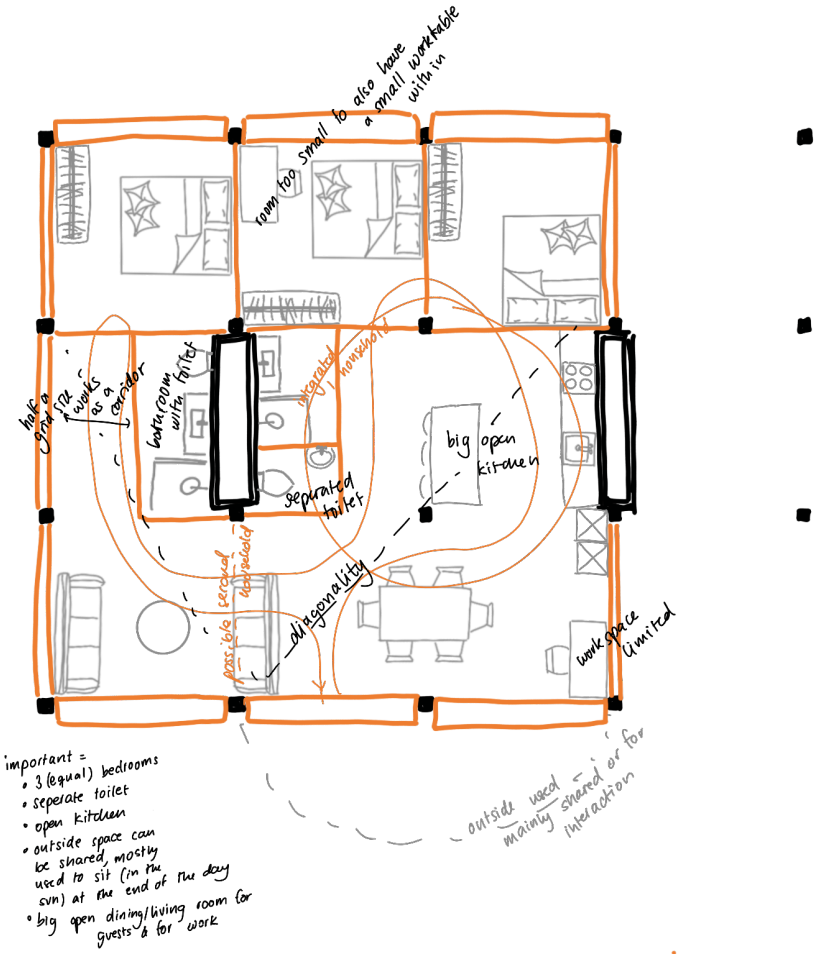


on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall(s) = interior partition wall(s)



type c household tests (cont.).

3.6x3.6m grid (based on *laan van de vrede & a simplification of modulus matrix*).



important =
- 3 (equal) bedrooms
- seperate toilet
- open kitchen
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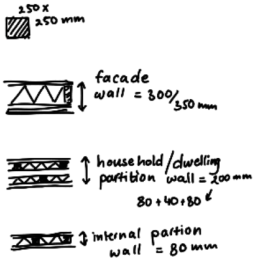
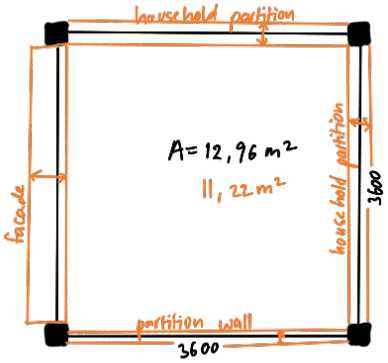
- big open dining/living room for guests & for work

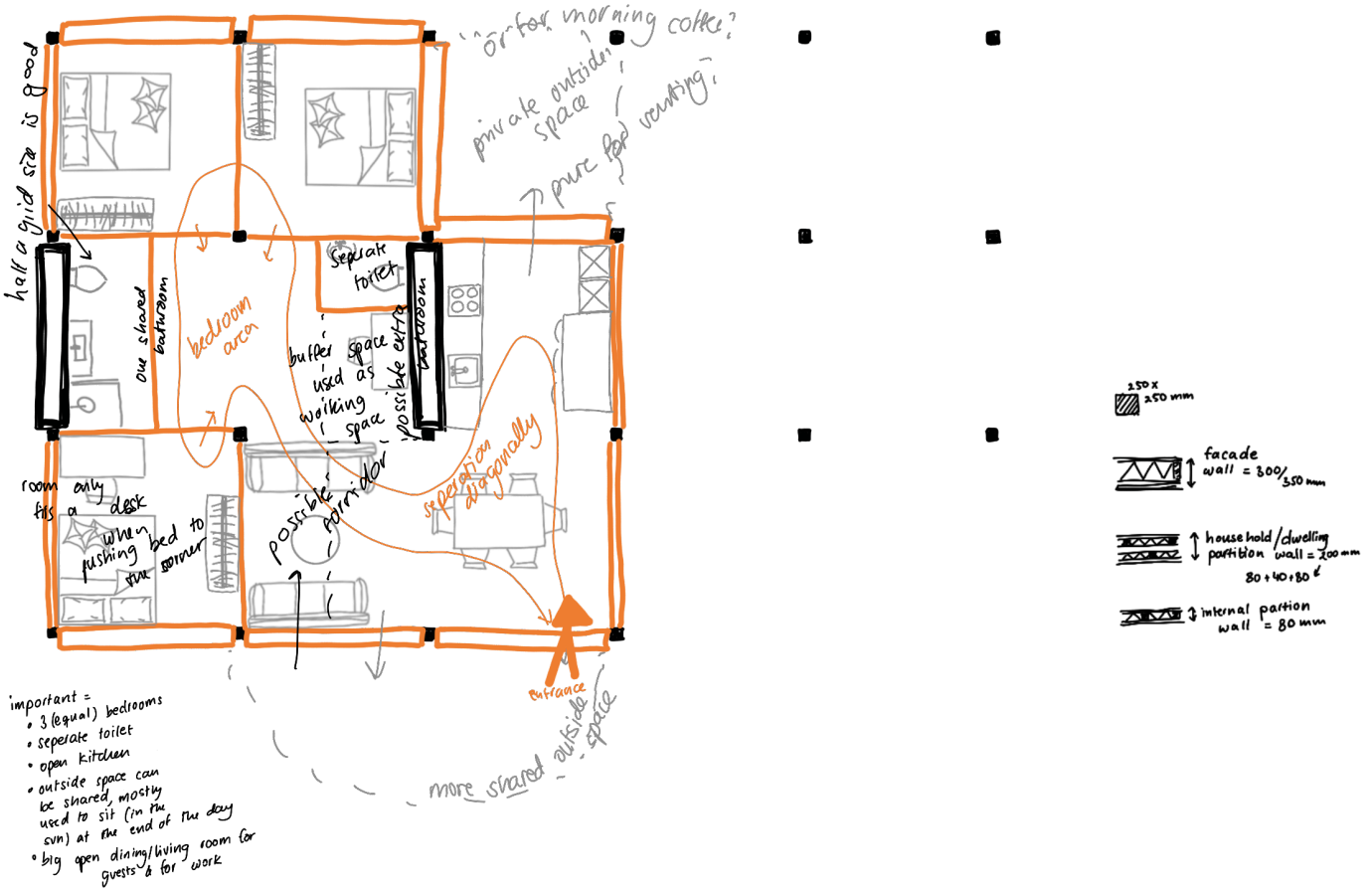


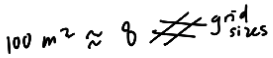
100 m² ≈ 9 ~~grid~~ sizes

on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall (s) = interior partition wall(s)

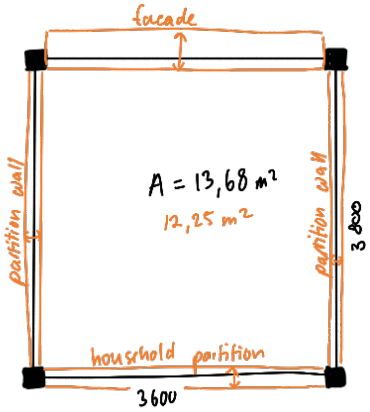


3.6x3.8m grid (based on *san riemo*).



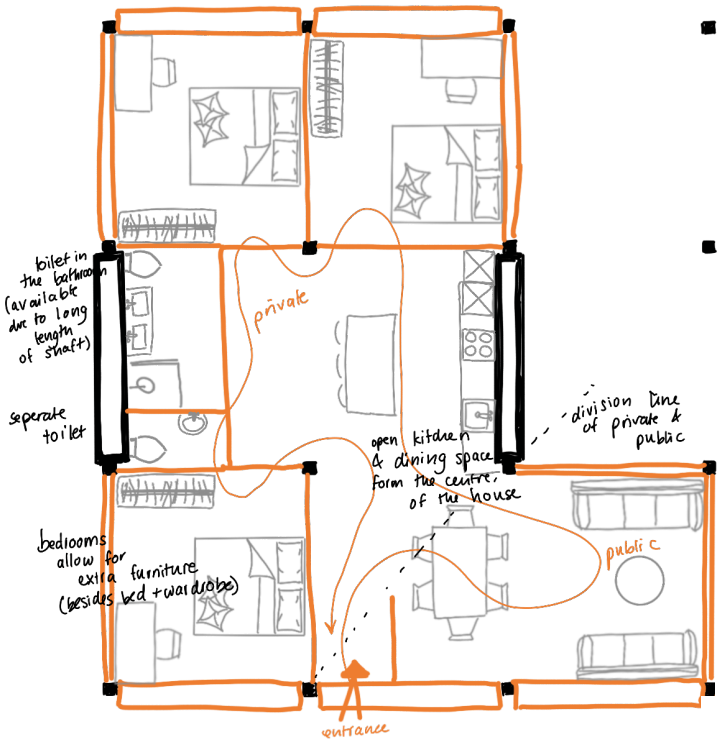


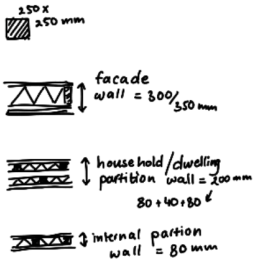
on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall(s) = interior partition wall(s)



type c household tests (cont.).

3.8x4.2m grid (based on *la borda*).

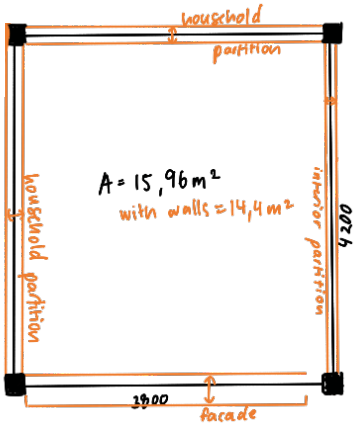




important =
- 3 (equal) bedrooms
- seperate toilet
- open kitchen
- outside space can be shared, mostly used to sit (in the sun) at the end of the day
- big open dining/living room for guests & for work

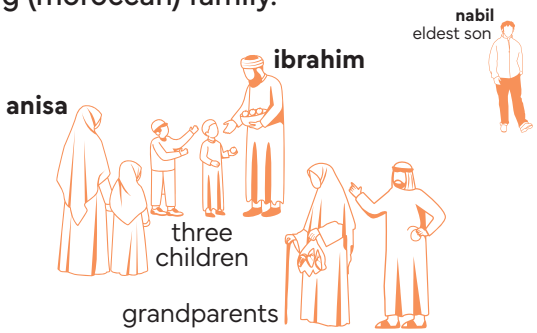
100 m² ≈ 7 ~~#~~ grid size

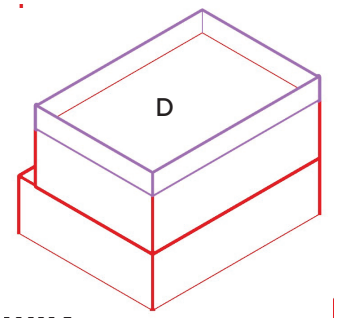
on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall (s) = interior partition wall(s)



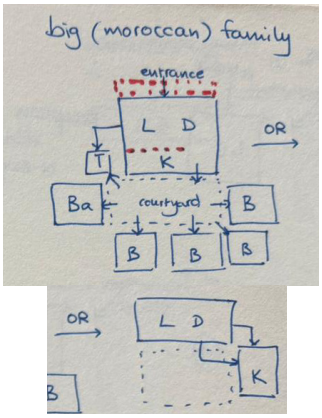
type d household.

big (moroccan) family.



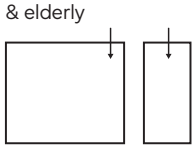


maximum
150m²



bathroom & toilet.

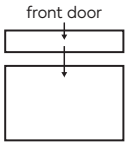
couples, shared housing, families & elderly



seperate

entrance.

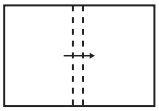
moroccan



indoor buffer

bedrooms.

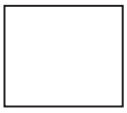
moroccan, indian, dutch, german & polish



preferably seperate, but studio is accepted when living alone

home office.

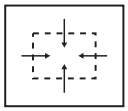
young singles & bigger families



office in the bedroom

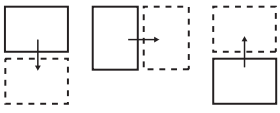
outside space.

moroccan



enclosed by house

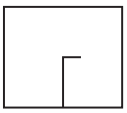
families & older couples/singles



private

kitchen.

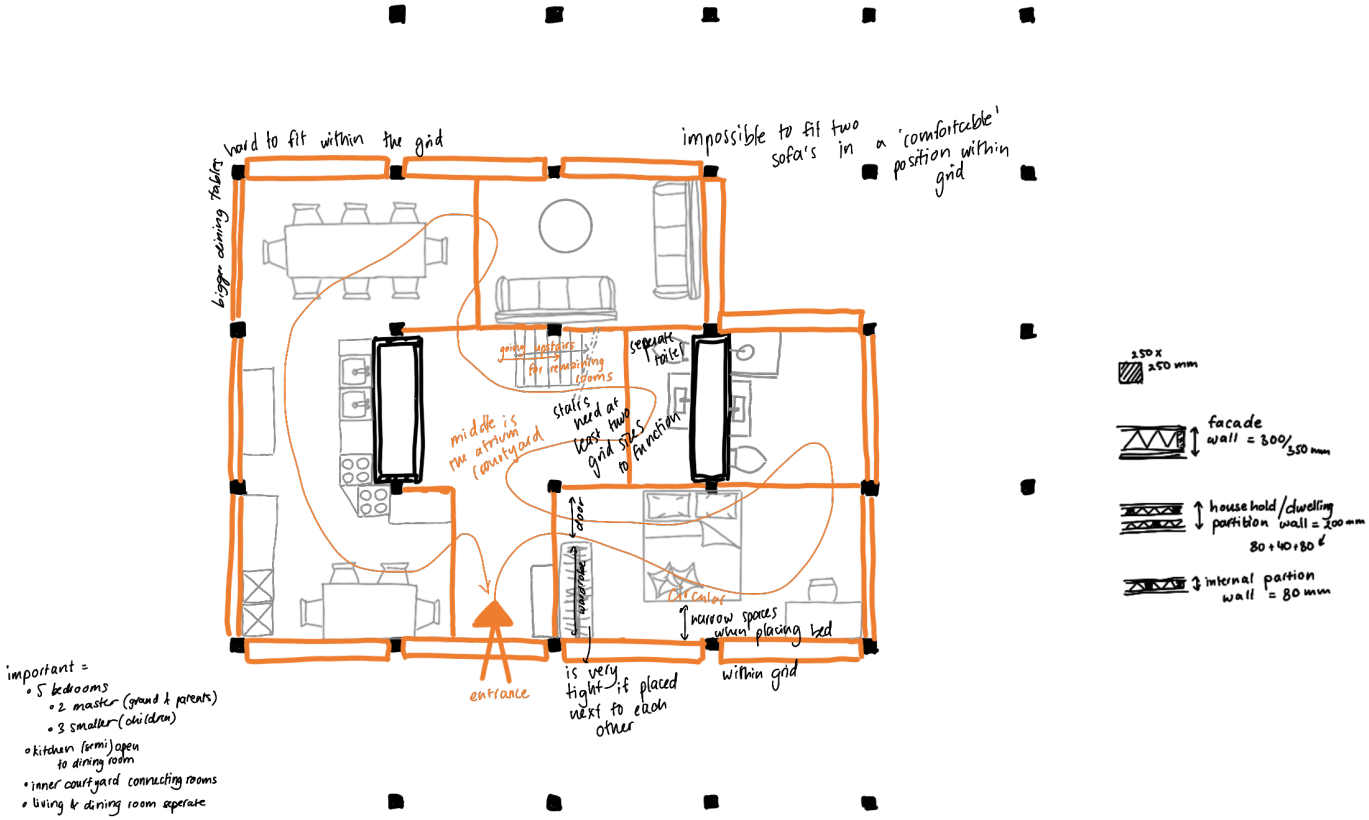
indian & moroccan



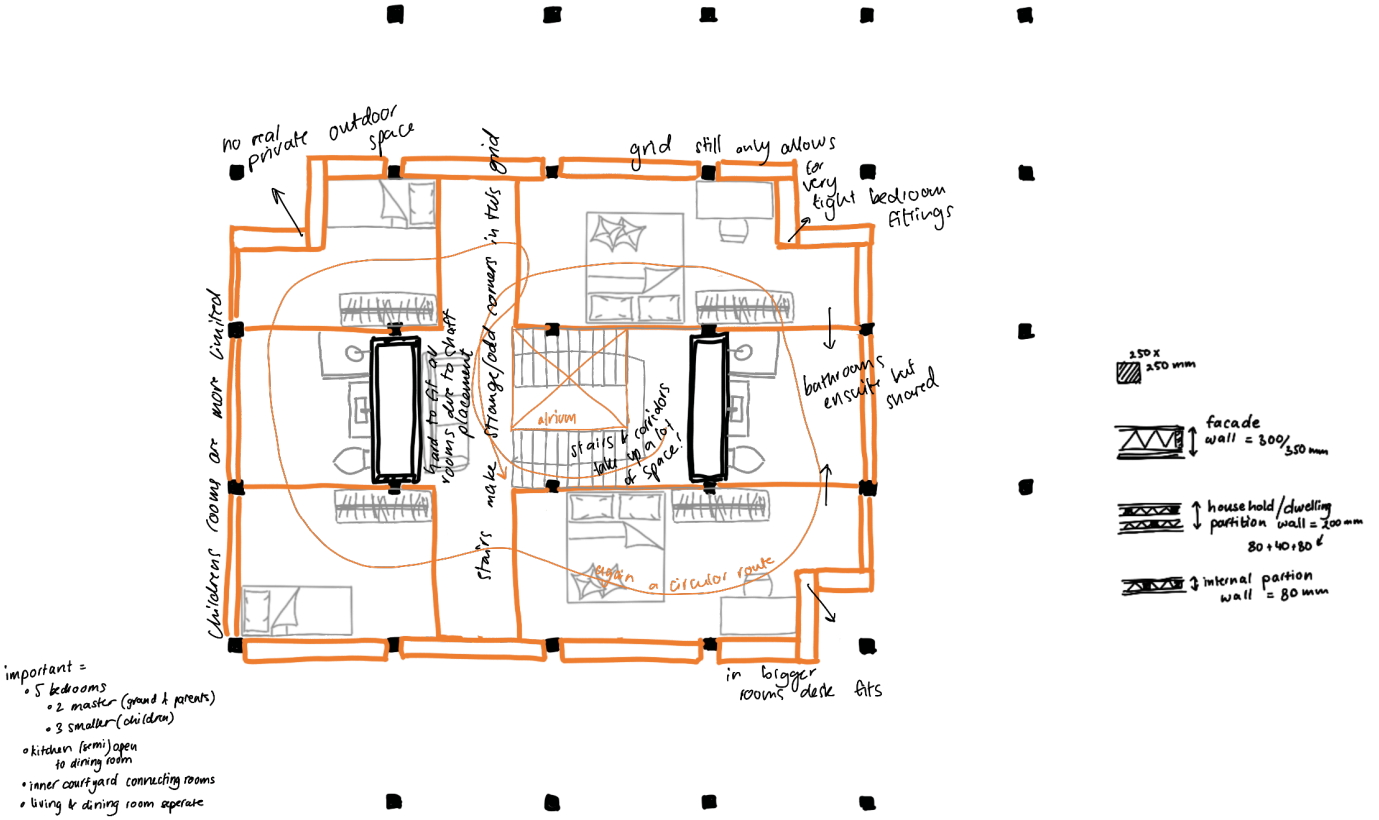
semi-open

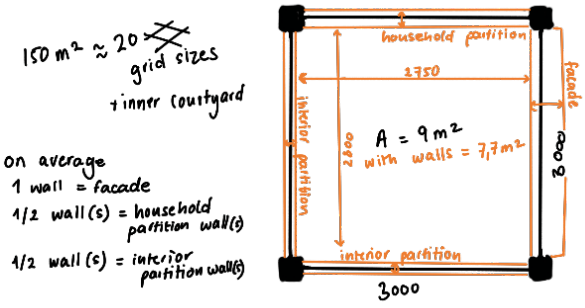
type d household tests.

3x3m grid, ground floor (based on *adaptive co-housing*).



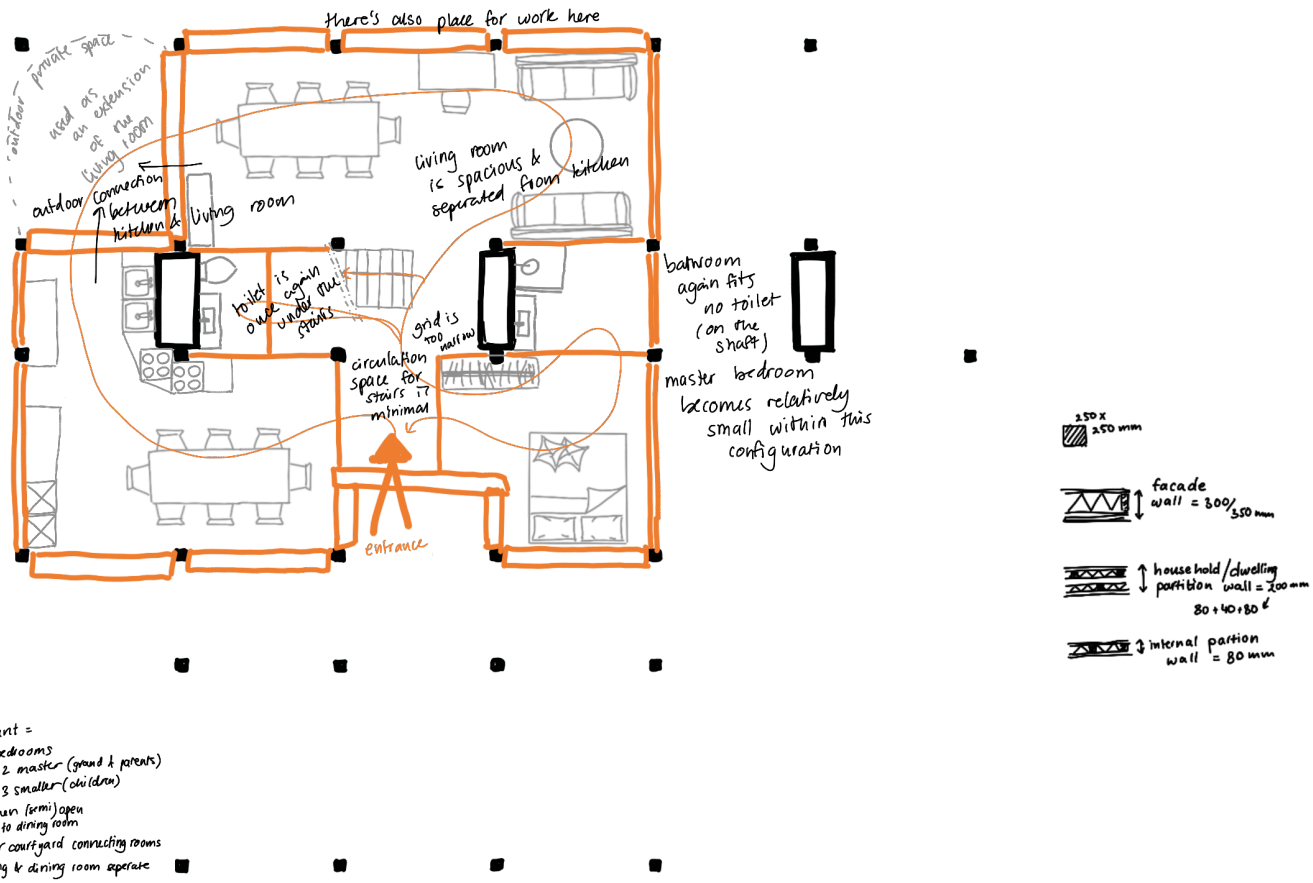
3x3m grid, first floor (based on *adaptive co-housing*).





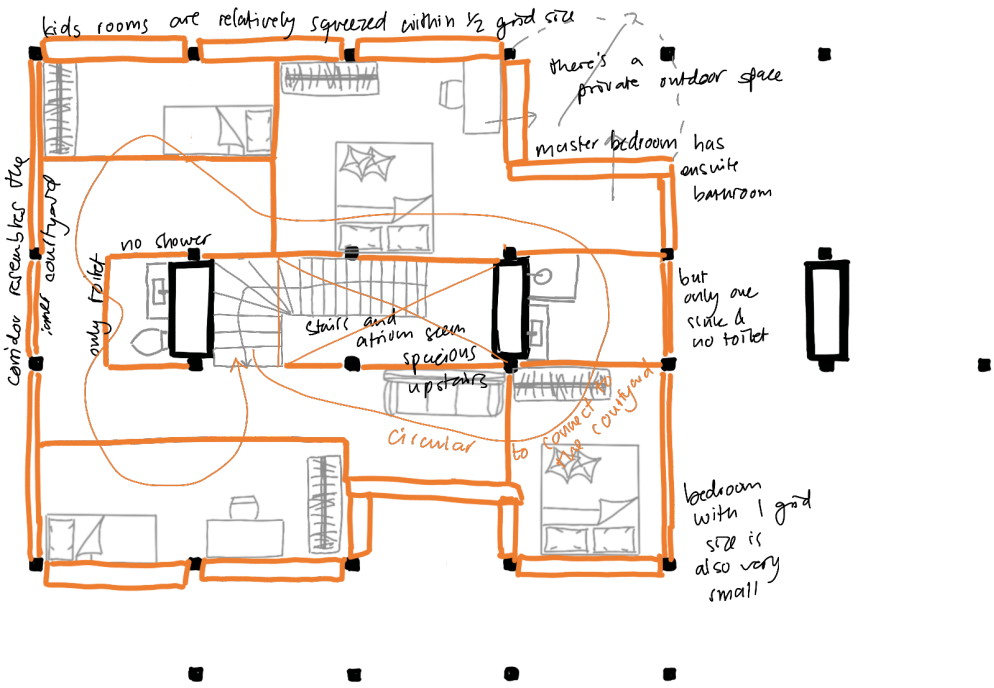
type d household tests.

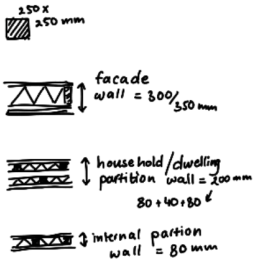
3x3.8m & 3x2.2m grid, ground floor (based on *quinta monroy*).



important =
- 5 bedrooms
  - 2 master (grand & parents)
  - 3 smaller (children)
- kitchen (semi) open to dining room
- inner courtyard connecting rooms
- living & dining room seperate

3x3.8m & 3x2.2m grid, first floor (based on *quinta monroy*).





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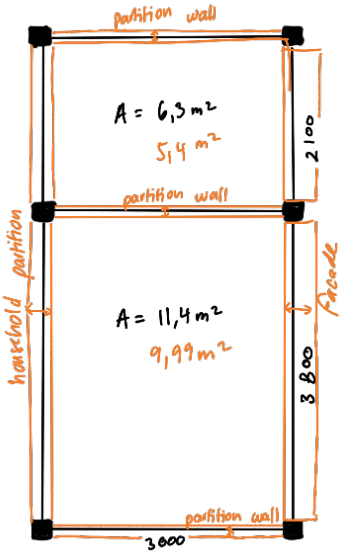
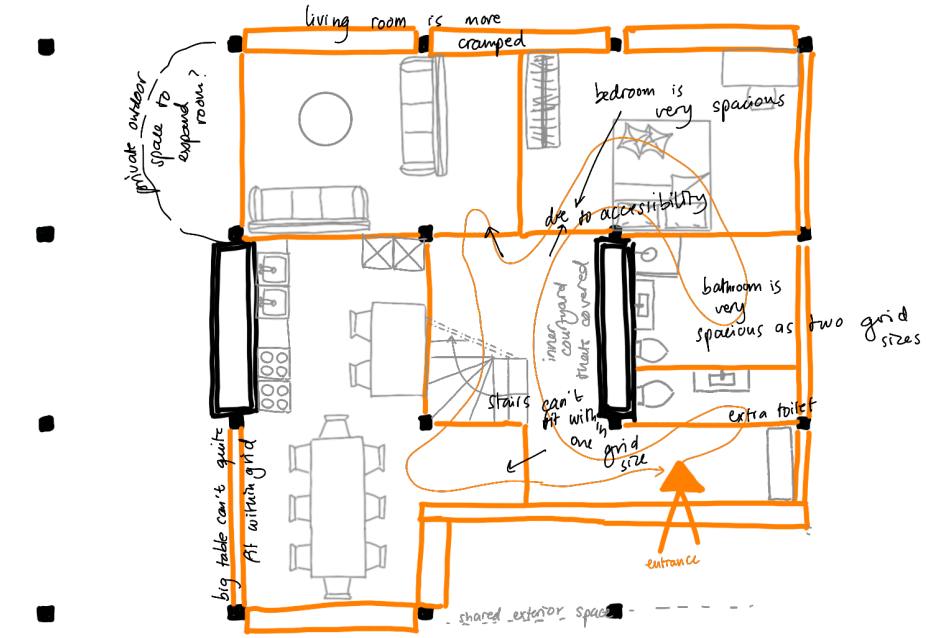


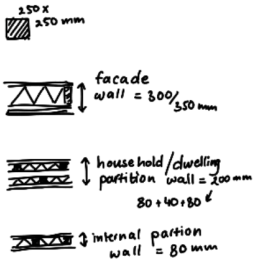
4 small ~~##~~ 6 small ~~##~~
150 m² ≈ 13 big ~~##~~ or 12 big ~~##~~
+ courtyard

on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall(s) = interior partition wall(s)

type d household tests (cont.).

3.6x3.6m grid, ground floor (based on *laan van de vrede & a simplification of modulus matrix*).





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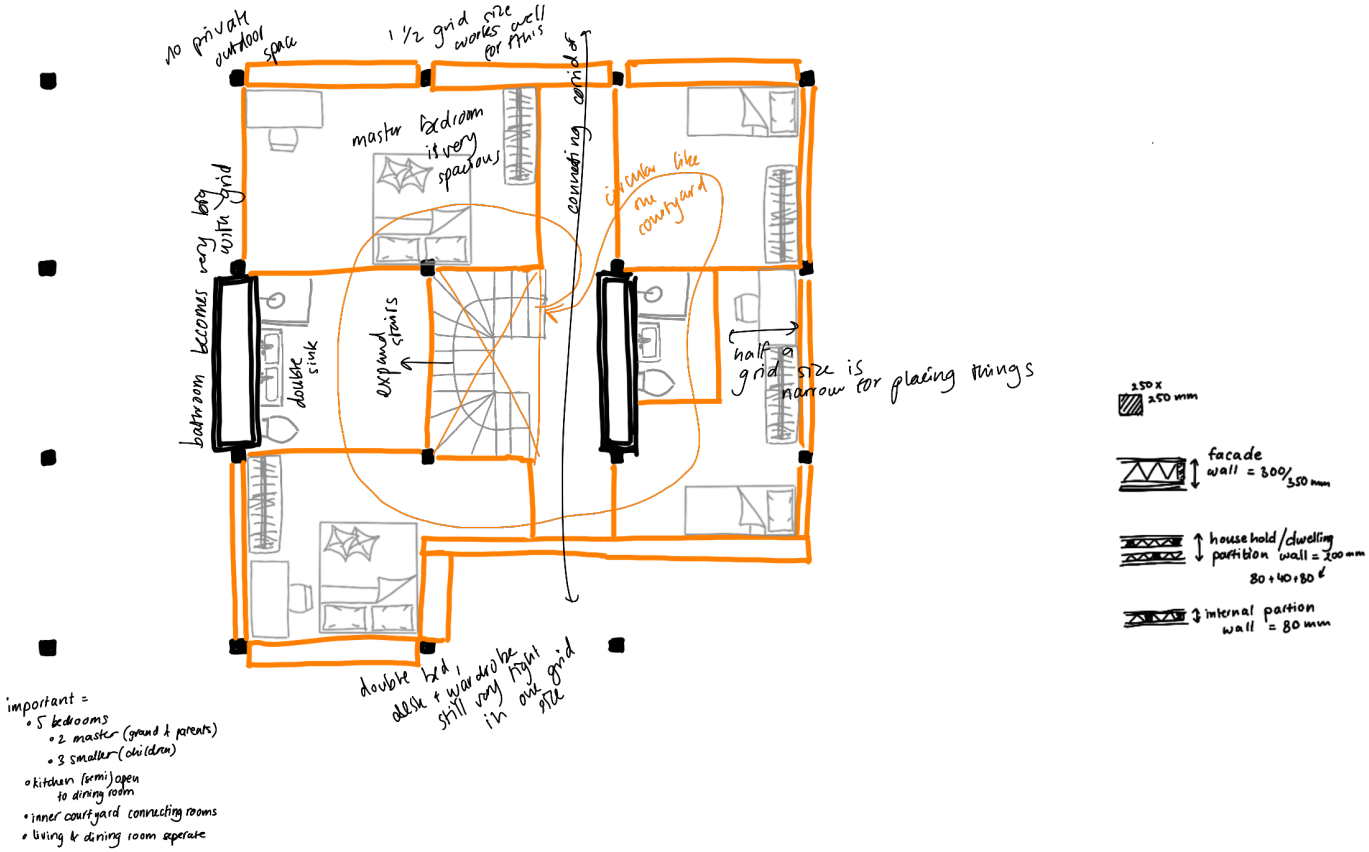
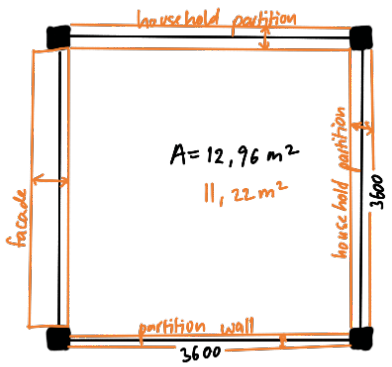
- 5 bedrooms
  - 2 master (grand & parents)
  - 3 smaller (children)
- kitchen (semi) open to dining room
- inner courtyard connecting rooms
- living & dining room seperate

3.6x3.6m grid, first floor (based on *laan van de vrede & a simplification of modulus matrix*).



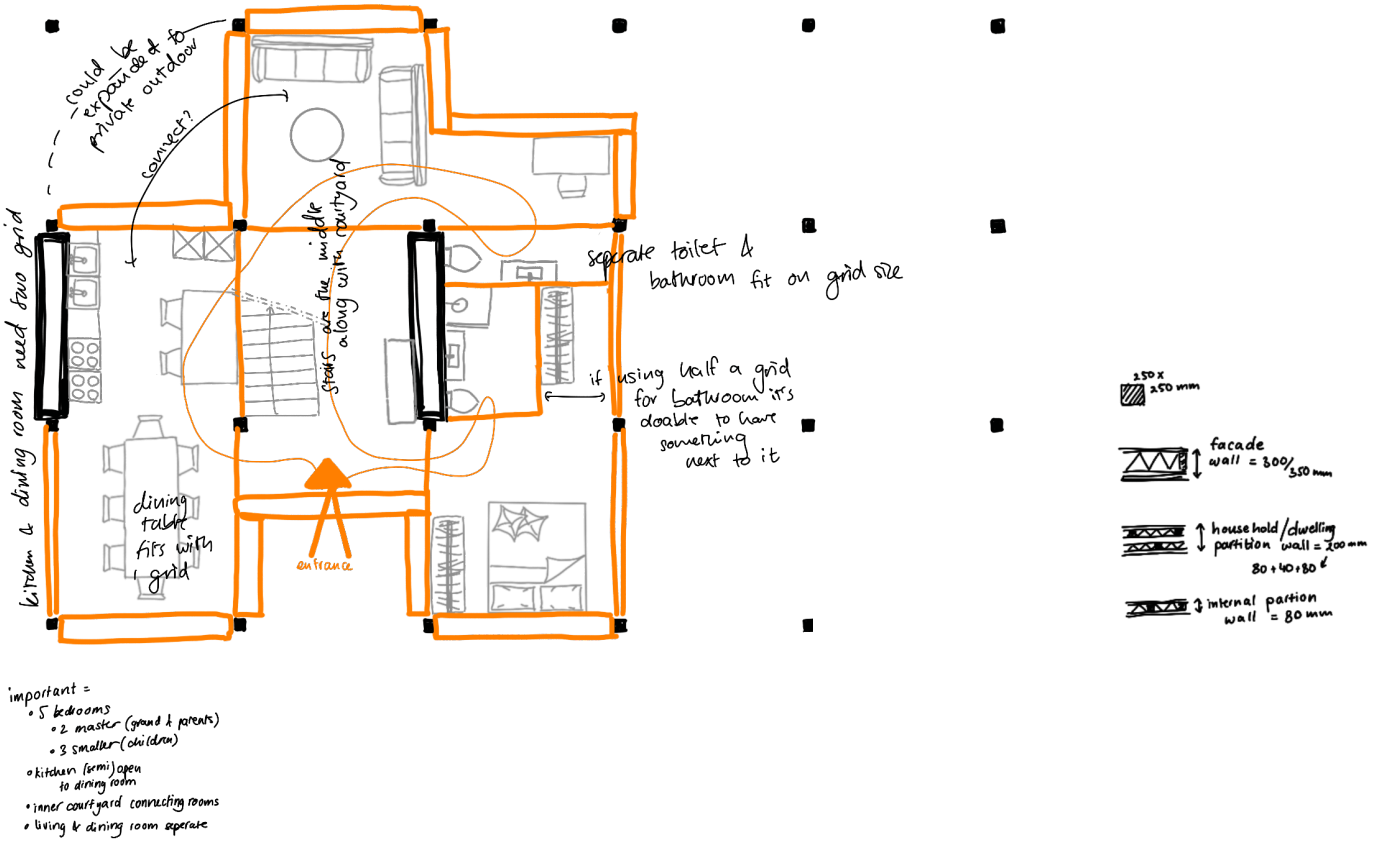
150 m² ≈ 13,5 ~~grid sizes~~
+ courtyard

on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall(s) = interior partition wall(s)



type d household tests (cont.).

3.6x3.8m grid, ground floor (based on *san riemo*).



important =
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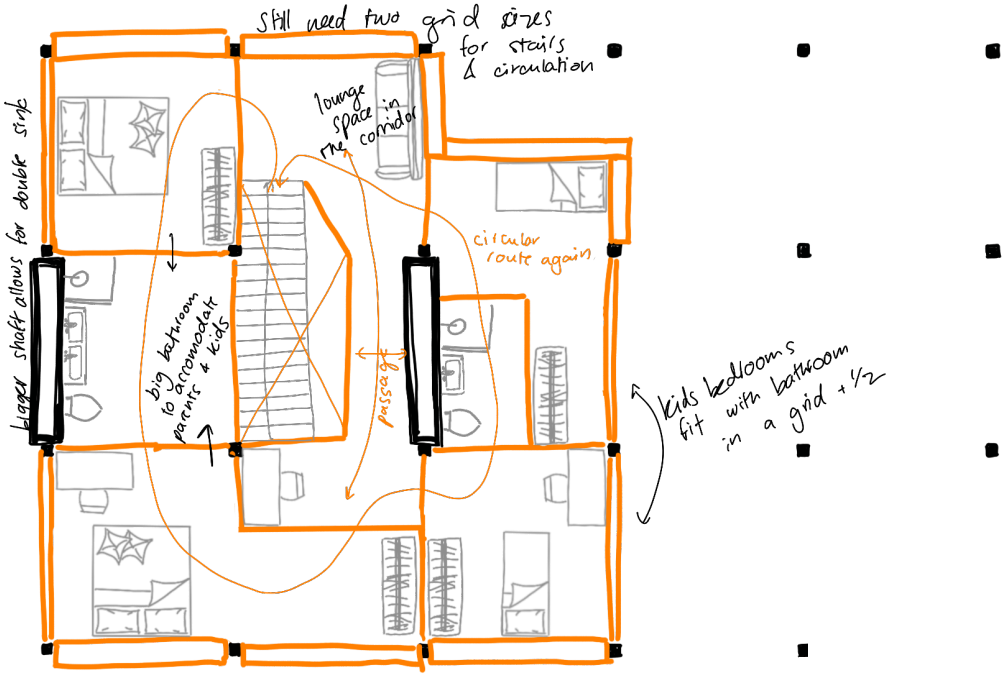
  - 2 master (grand & parents)
  - 3 smaller (children)
- kitchen (semi) open to dining room
- inner courtyard connecting rooms
- living & dining room seperate

3.6x3.8m grid, first floor (based on *san riemo*).



important =
- 5 bedrooms
  - 2 master (ground & parents)
  - 3 smaller (children)
- kitchen (semi) open to dining room
- inner courtyard connecting rooms
- living & dining room seperate

250 x 250 mm

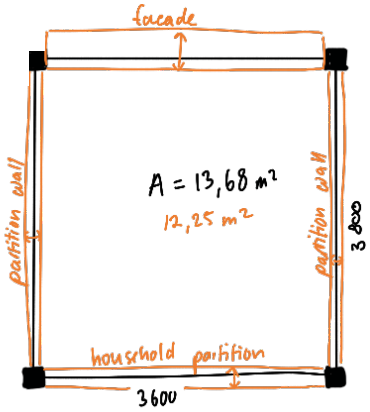
facade wall = 300/350 mm

household/dwelling partition wall = 200 mm
80 + 40 + 80

internal partion wall = 80 mm

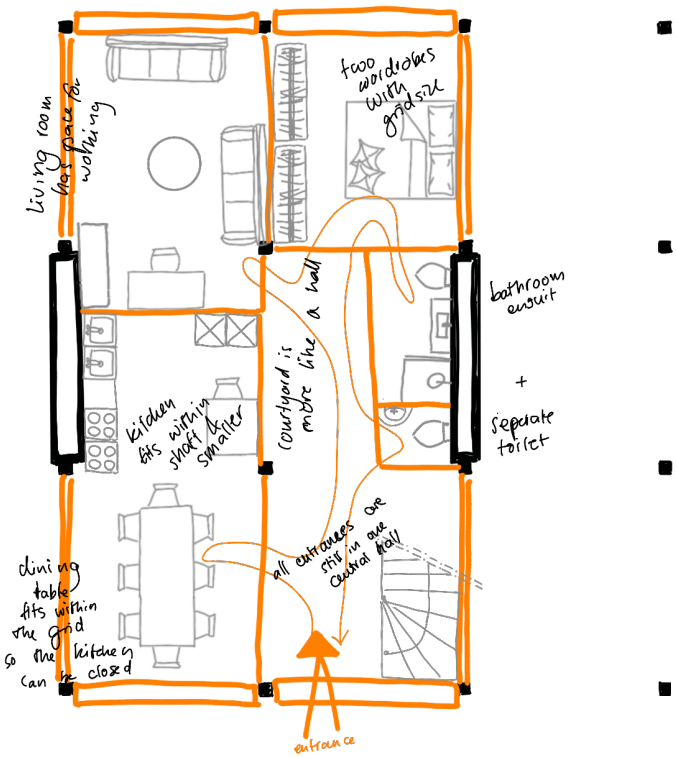
150 m² ≈ 12 ~~grid~~ sizes
+ courtyard

on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall(s) = interior partition wall(s)

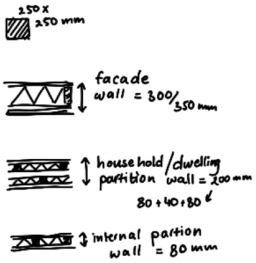


type d household tests (cont.).

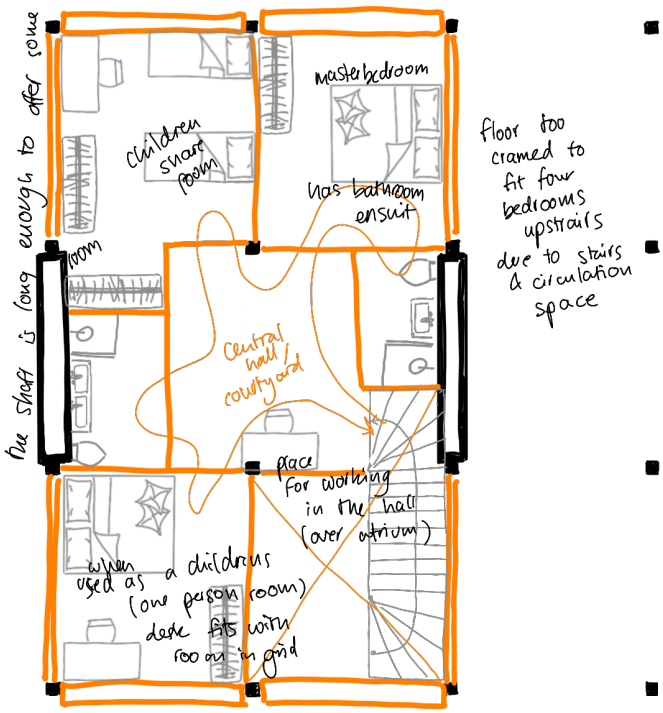
3.8x4.2m grid, ground floor (based on *la borda*).

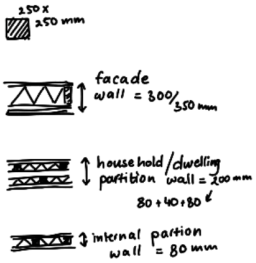


important =
- 5 bedrooms
  - 2 master (ground & parents)
  - 3 smaller (children)
- kitchen (semi) open to dining room
- inner courtyard connecting rooms
- living & dining room seperate



3.8x4.2m grid, first floor (based on *la borda*).

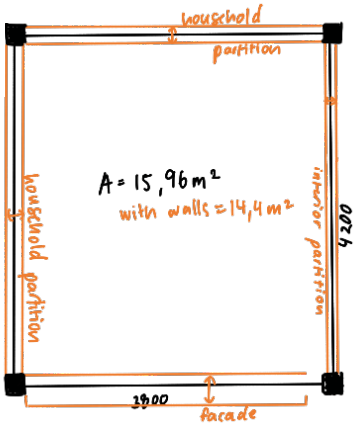




important =
- 5 bedrooms
  - 2 master (grand & parents)
  - 3 smaller (children)
- kitchen (semi) open to dining room
- inner courtyard connecting rooms
- living & dining room seperate

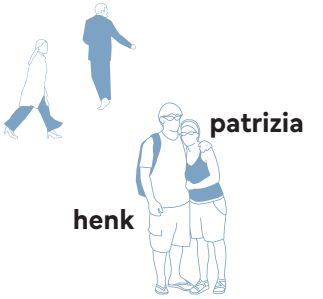
150 m² ≈ 10,5 ~~//~~ grid size + courtyard

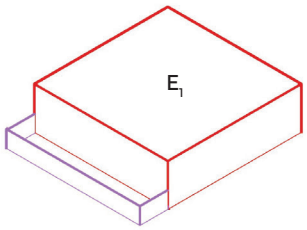
on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall (s) = interior partition wall(s)



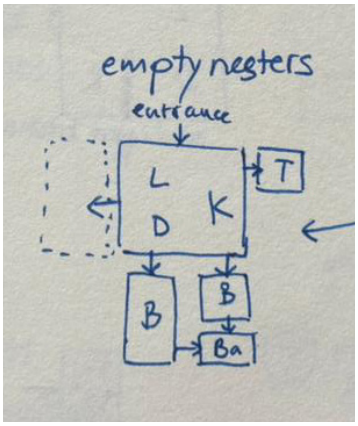
type e households.

(german & dutch) emptynesters.



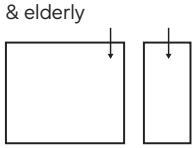


maximum
90m²



bathroom & toilet.

couples, shared housing, families & elderly

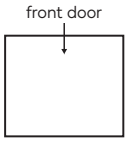


seperate

entrance.

all other cultures

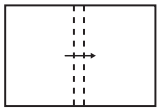
front door



no need for buffer

bedrooms.

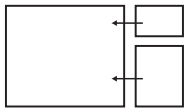
moroccan, indian, dutch, german & polish



preferably seperate, but studio is accepted when living alone

home office.

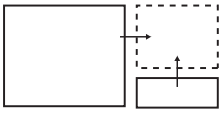
elderly



no office, but guest bedroom

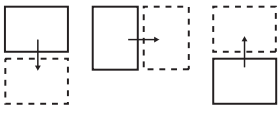
outside space.

indian, turkish, indonesian, dutch, german & polish



connected to kitchen and/or living (& dining) room

families & older couples/singles



private

kitchen.

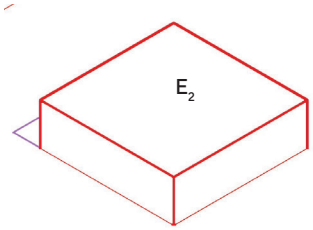
dutch, german & polish



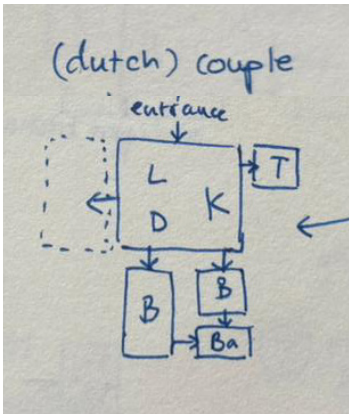
open

elderly (dutch) couple.



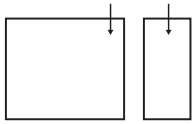


maximum
90m²



bathroom & toilet.

couples, shared housing, families & elderly

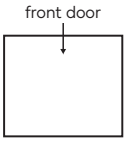


seperate

entrance.

all other cultures

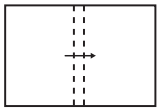
front door



no need for buffer

bedrooms.

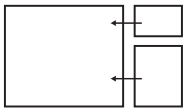
moroccan, indian, dutch, german & polish



preferably seperate, but studio is accepted when living alone

home office.

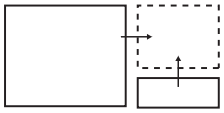
elderly



no office, but guest bedroom

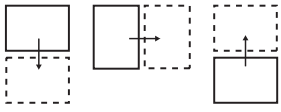
outside space.

indian, turkish, indonesian, dutch, german & polish



connected to kitchen and/or living (& dining) room

families & older couples/singles



private

kitchen.

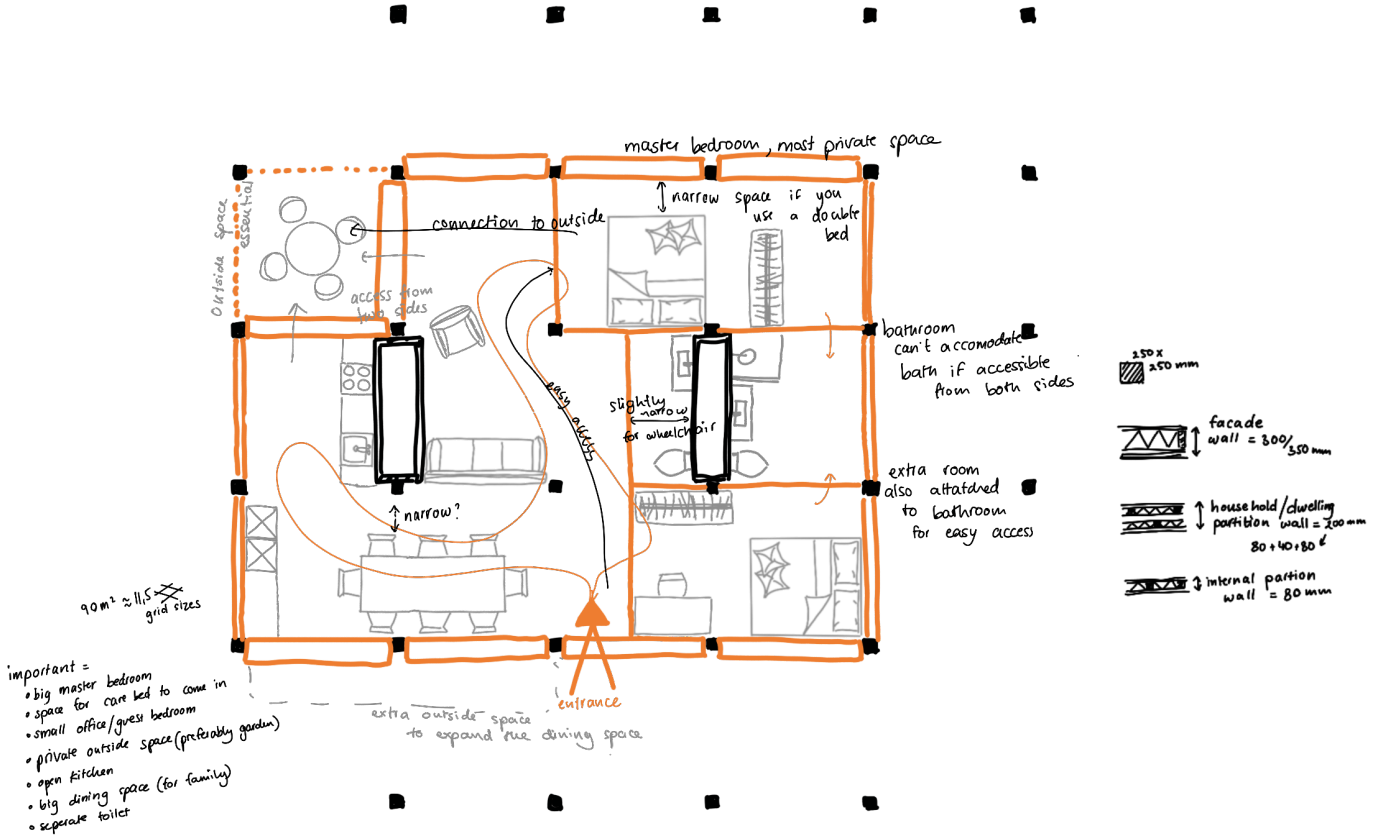
dutch, german & polish

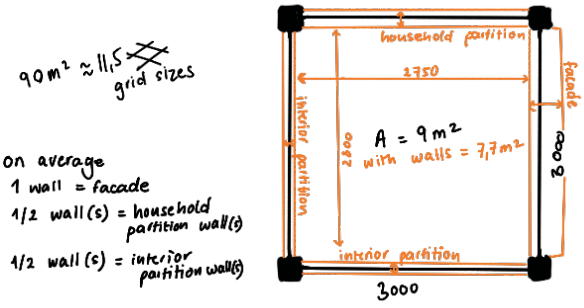


open

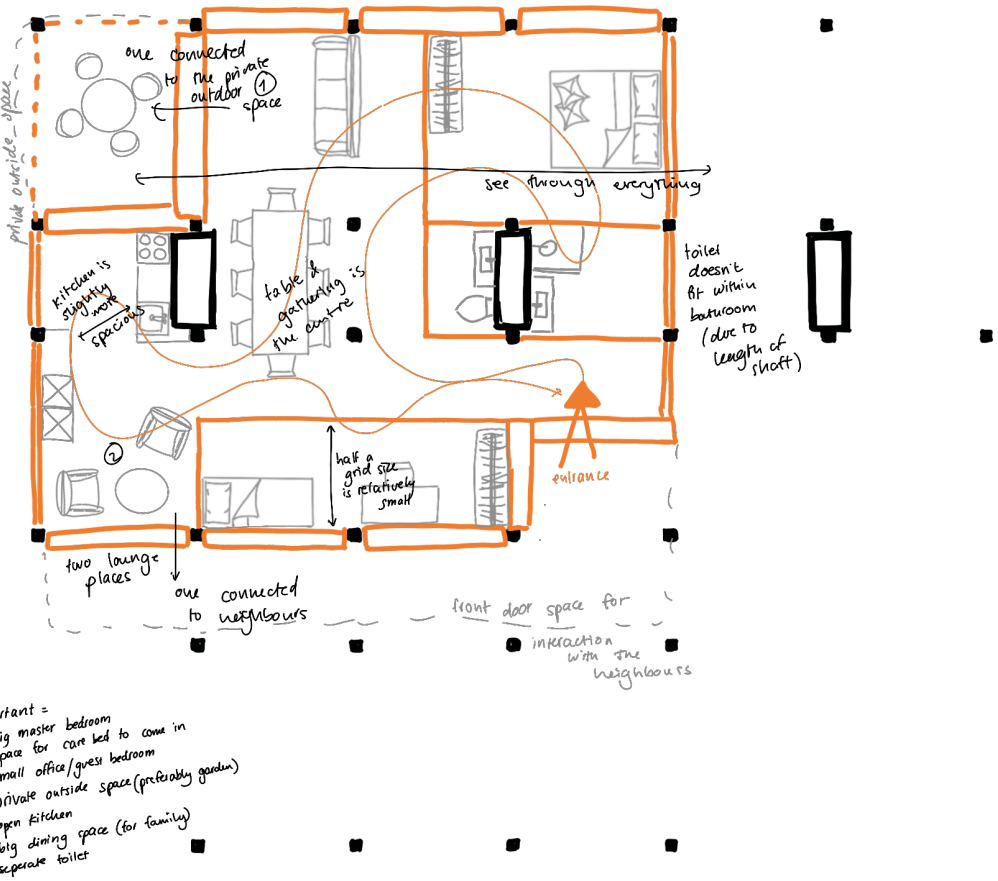
type e household tests.

3x3m grid (based on *adaptive co-housing*).

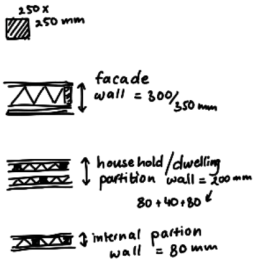


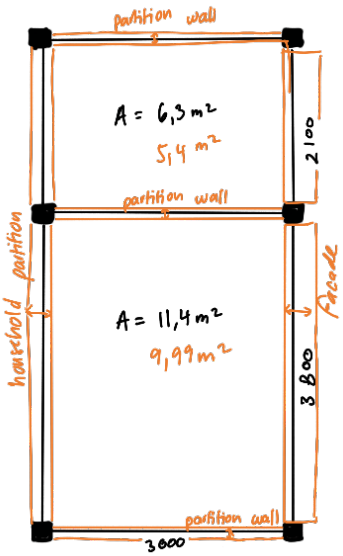


3x3.8m & 3x2.2m grid (based on *quinta monroy*).



important =
- big master bedroom
- space for care bed to come in
- small office/guest bedroom
- private outside space (preferably garden)
- open kitchen
- big dining space (for family)
- seperate toilet



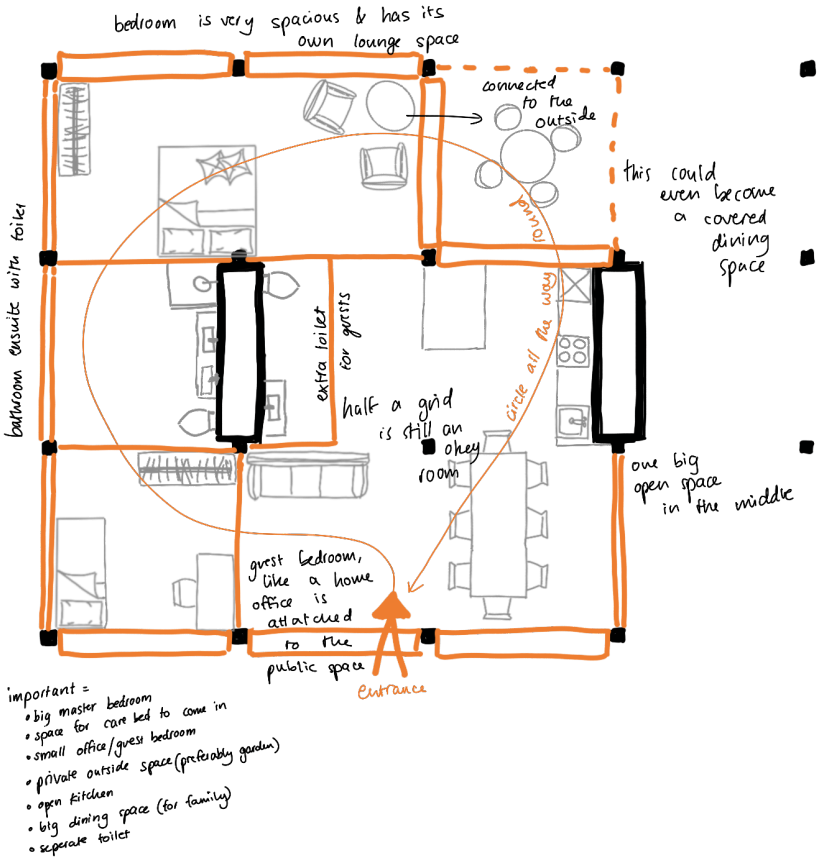


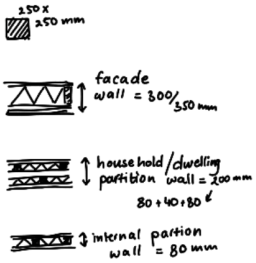
3 small ~~small~~ 4 small ~~small~~
0 m² ≈ 7 big ~~big~~ or 6,5 big ~~big~~

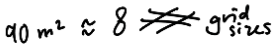
on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall(s) = interior partition wall(s)

type e household tests (cont.).

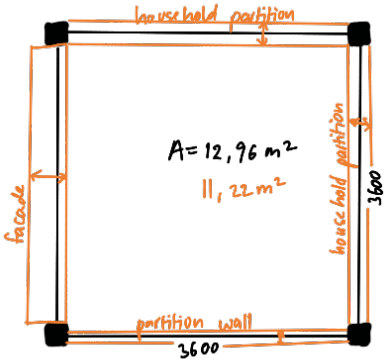
3.6x3.6m grid (based on *laan van de vrede & a simplification of modulus matrix*).



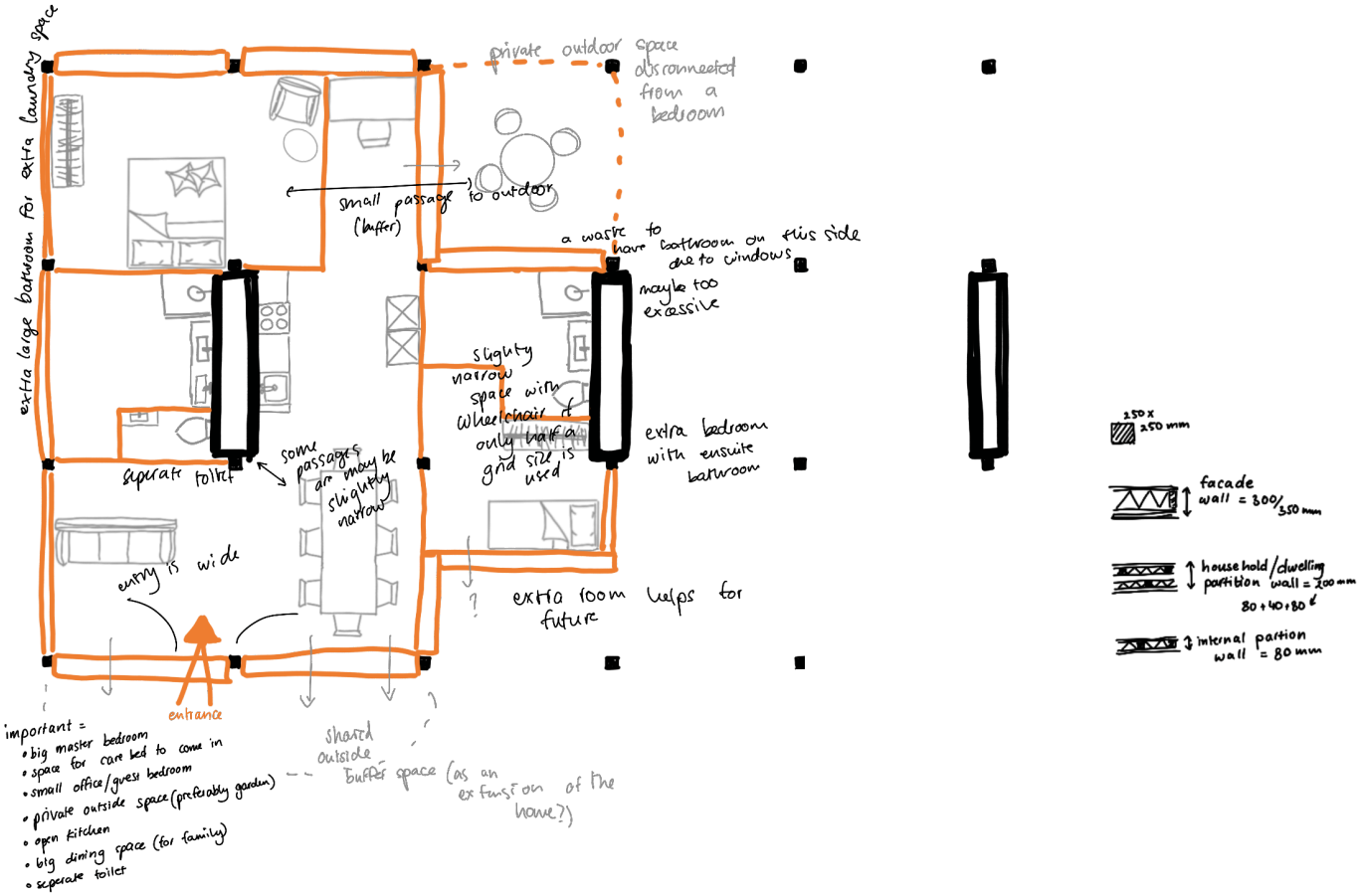


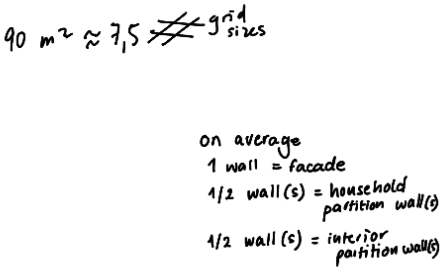


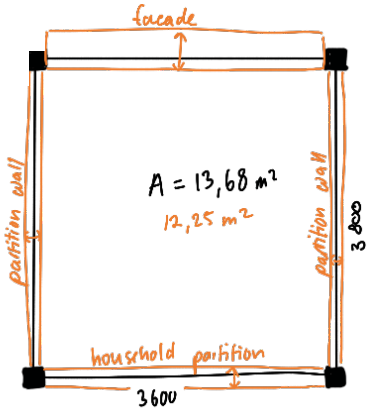
on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall(s) = interior partition wall(s)



3.6x3.8m grid (based on *san riemo*).

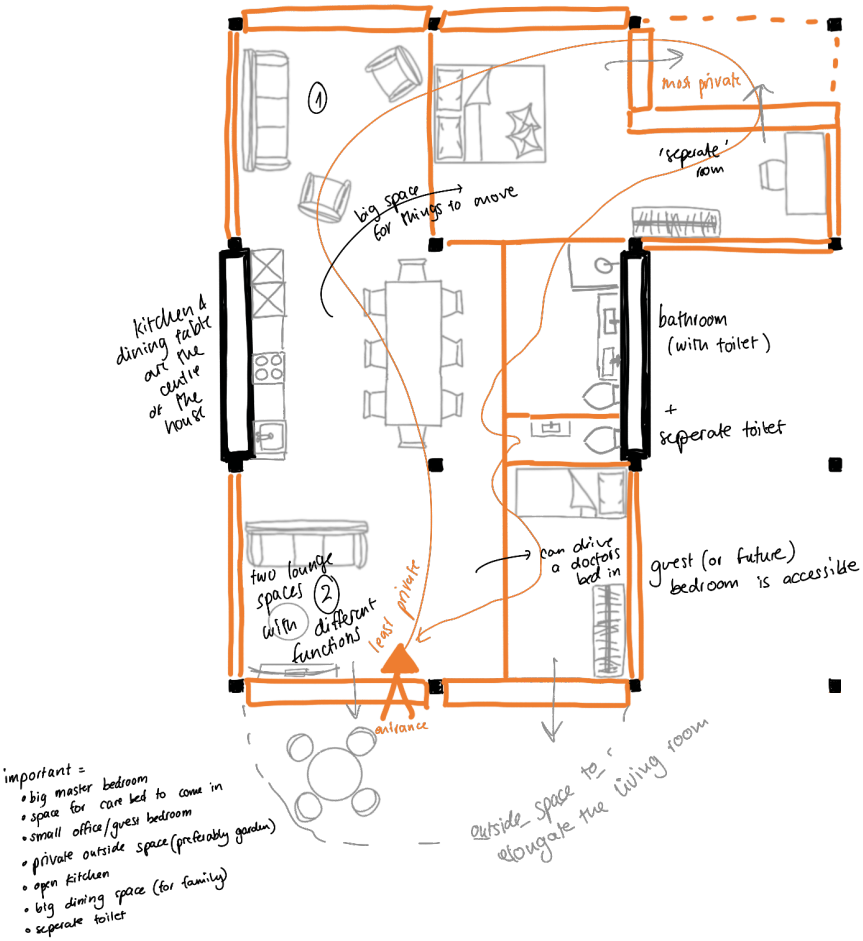


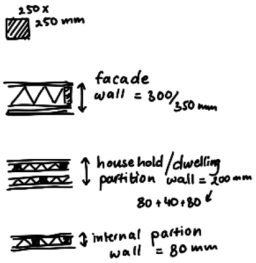




type e household tests (cont.).

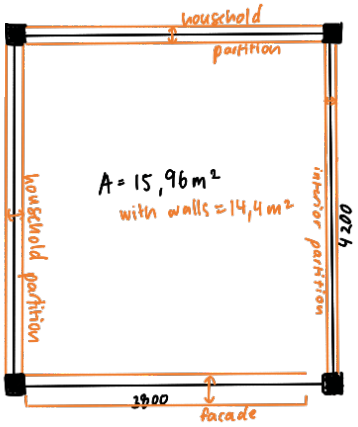
3.8x4.2m grid (based on *la borda*).





90 m² ≈ 6,5 ~~#~~ grid size

on average
1 wall = facade
1/2 wall(s) = household partition wall(s)
1/2 wall(s) = interior partition wall(s)



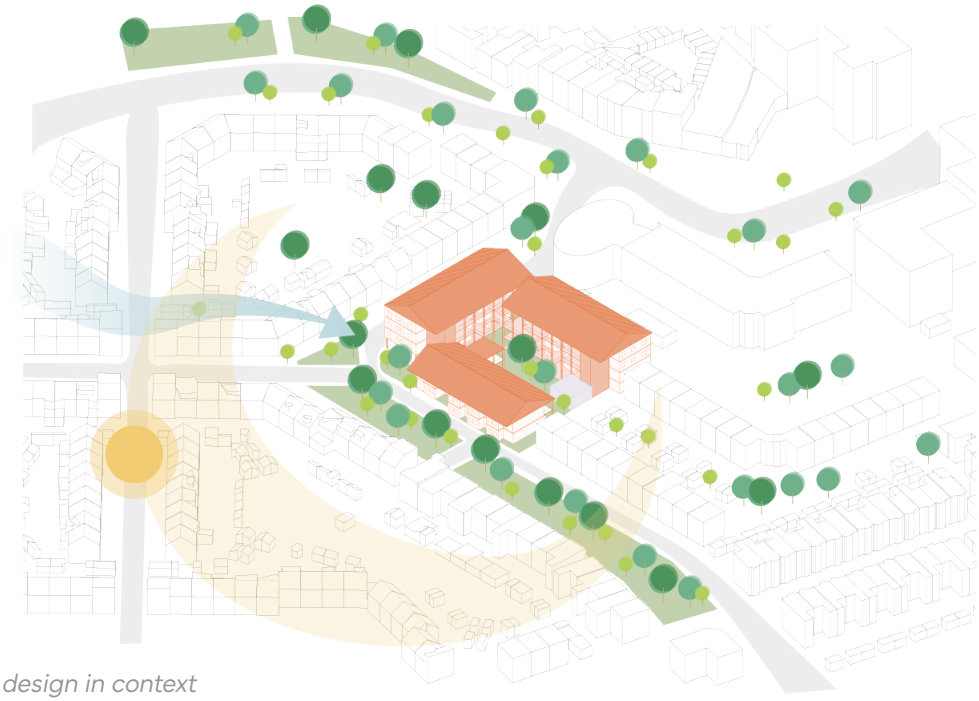
conclusion.

By summarising the main pain points into a table, it is quite clear that the smaller sizes were never going to work for the choosen households. The initial choice for 3.6x3.6m still turns out to be one of the better options, but as we have seen in the A2 prototype. The reason not to choose this size is mainly based on the fact that it lacked direction, which made the circulation space within the house oddly & narrowly shaped. Therefore, choosing a size that resembles the two bigger grid is ideal. The biggest grid size (3.8x4.2m) seems to have the least issues, and those it has are regarding the overdimensioning. The choice is to then choose a size that is similar in ratio, but slightly smaller: 3.7x4.05m.

	type a households.	type b households.	type c households.	type d household.	type e households.
3x3m adaptive co-housing.	desk space/work space is hard to fit in the shaft is too small to add all utilities (like toilet)	grid is too limiting to fit the different types of spaces with the square meterage	bedrooms have to be at least 2 grid sizes (which takes up a lot of space)	the master bedroom becomes very tight (even with two grid sizes) living room is too small for the family	small grid size allows for good seethroughs from facade to facade 1/2 grid too small for toilet space
3x3.8m + 3x2.2m quinta monroy.	kitchen (dining) table is very much squeezed the shaft is too small to add all utilities (like toilet)	the shaft is too small to add all the utilities needed	bedrooms become too small, and don't fit a working desk in the shaft is too small to add all utilities	the shaft is too small to add all utilities (like toilet) bedrooms (master & kids) become crambed	guest room/home office is very much squezzed within this grid
3.6x3.6m laan v/d vrede & modulus matrix.	✓ **best option**	✓ **best option**	bedrooms are still too small to have a working space inside them (the grid does facilitate working space in the living room)	kitchen can't be semi-open, dining table doesn't fit in one grid size desk doesn't fit in 1 grid size bedroom	✓ **best option**
3.6x3.8m san riemo.	kitchen (dining) table is very much squeezed the shaft is too small to add all utilities (like toilet)	✓ **best option**	slightly too small bedrooms but it's doable to have a desk in there	✓ **best option**	second toilet is either too big, or bathroom too small some odd (narrow) corners with non-symetrical grid
3.8x4.2m la borda.	✓ **best option**	excesively big grid by having shaft in the middle, the outside space is relatively far away	✓ **best option**	grid can only really accomodate 3 bedrooms upstairs due the stair space courtyard more symbolic	✓ **best option**

appendix e.

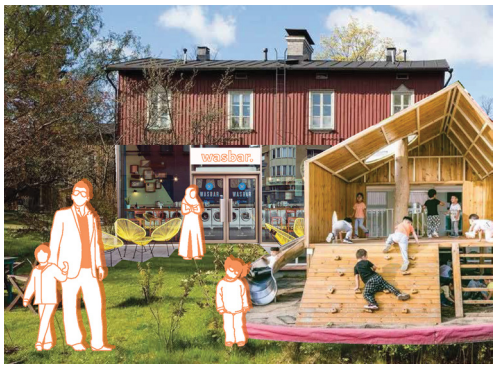
First fully developed design prototype, presented at the A2. All author's work.

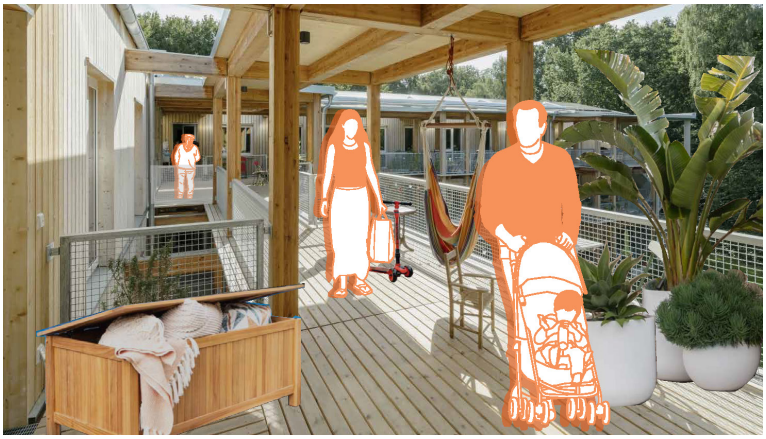


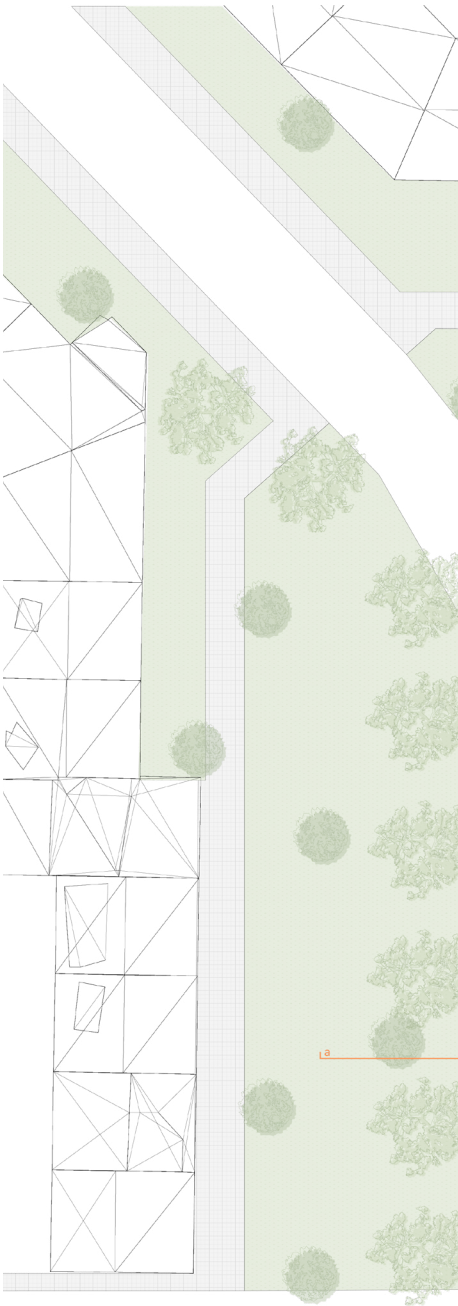
design in context

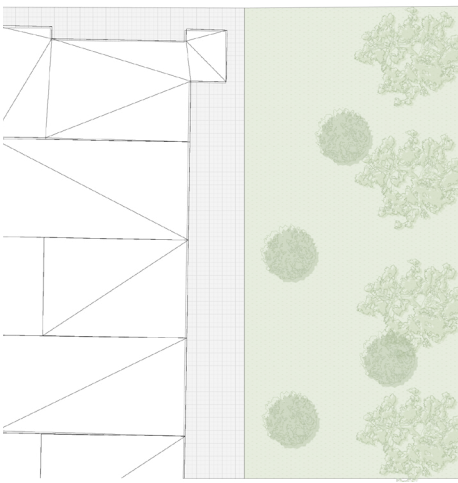
impression drawings



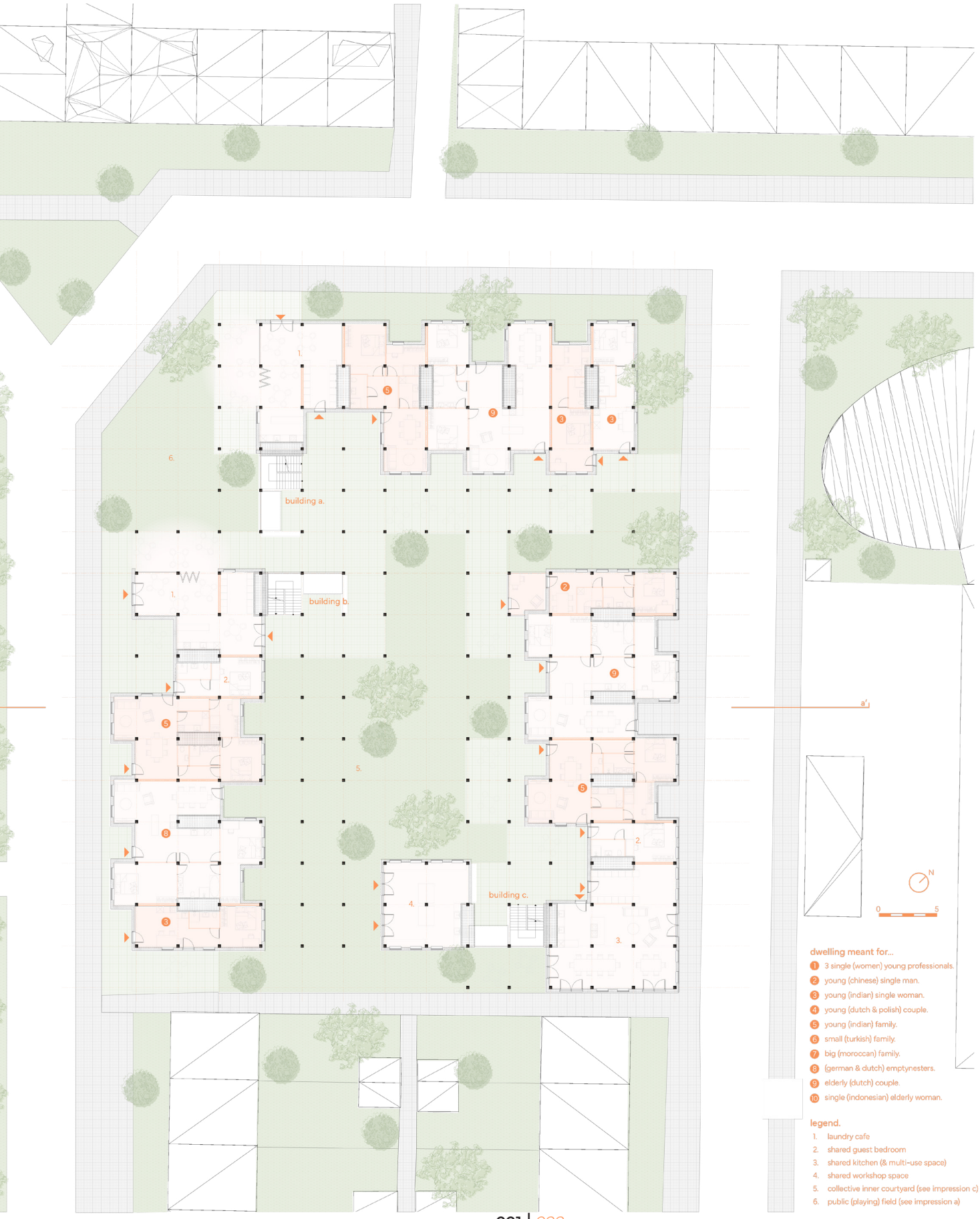








floorplan ground floor in site

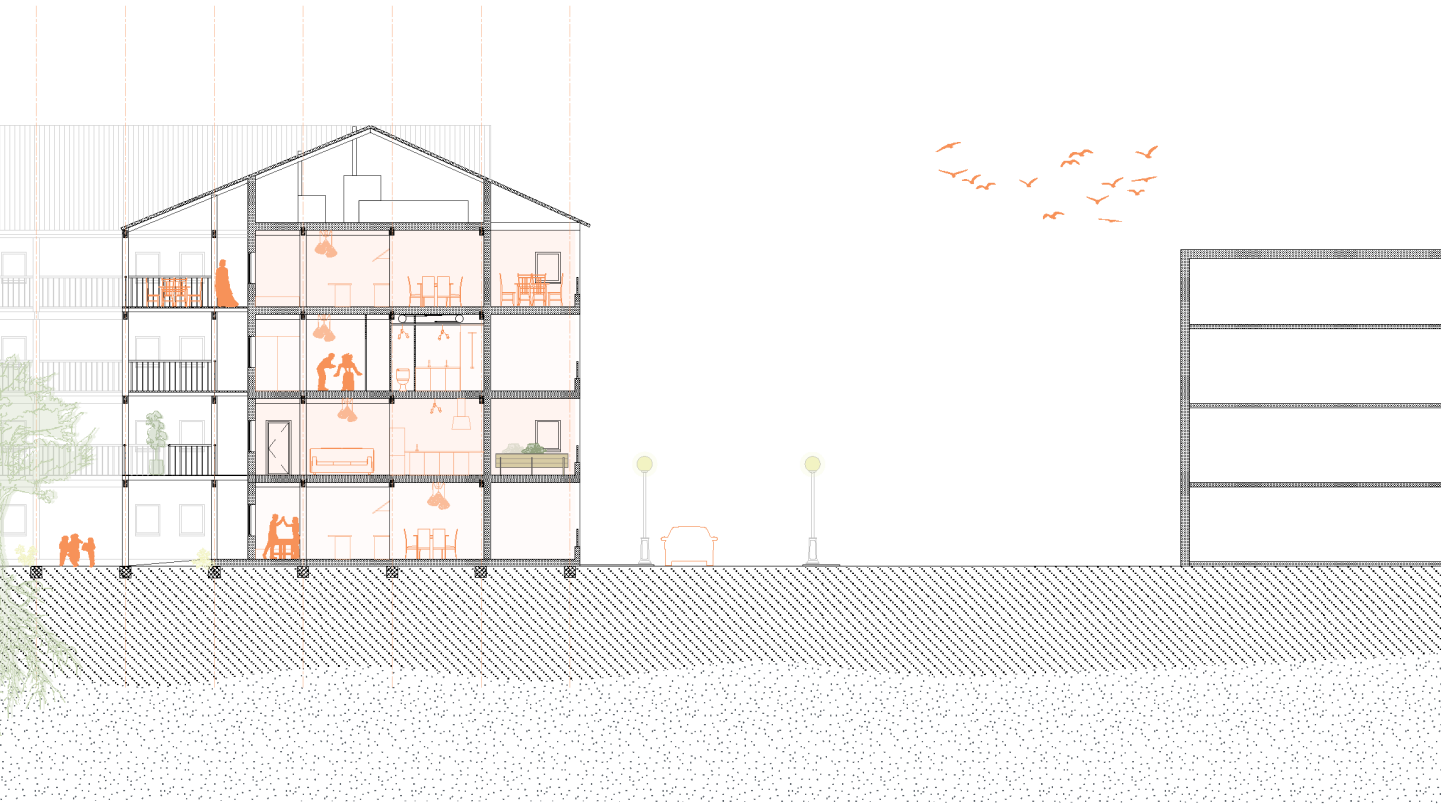

building a.
building b.
building c.
a'
N
0
5
dwelling meant for...
1 3 single (women) young professionals.
2 young (chinese) single man.
3 young (indian) single woman.
4 young (dutch & polish) couple.
5 young (indian) family.
6 small (turkish) family.
7 big (moroccan) family.
8 (german & dutch) emptynesters.
9 elderly (dutch) couple.
10 single (indonesian) elderly woman.
legend.
1. laundry cafe
2. shared guest bedroom
3. shared kitchen (& multi-use space)
4. shared workshop space
5. collective inner courtyard (see impression c)
6. public (playing) field (see impression a)







first floor



section aa'



second floor



third floor

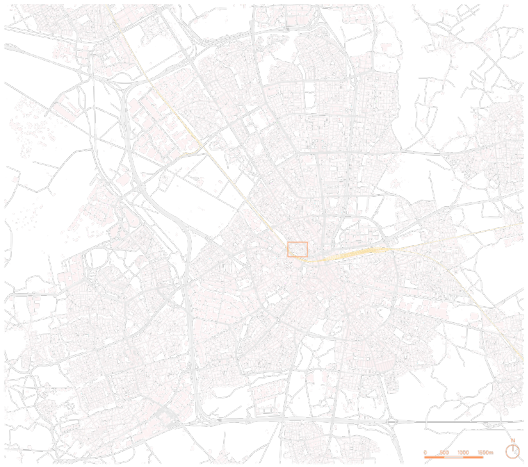
appendix f.

The final proposed design, in poster format. Scaled to fit page.

a home grown (old).

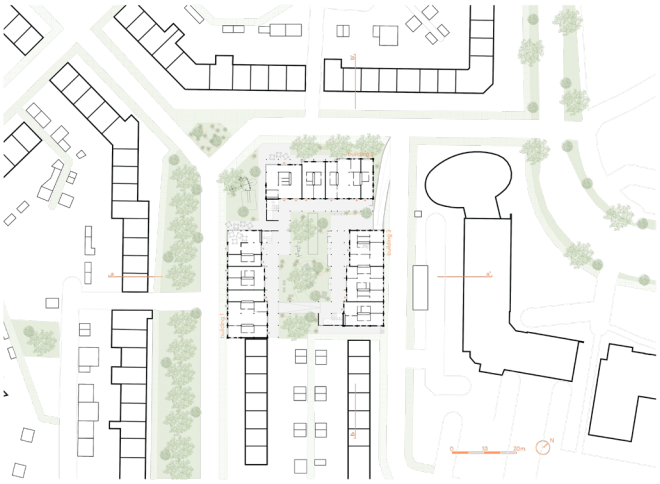
emma van barneveld.
5023629

context.





site.
scale 1:500.



section aa'.



section bb'.



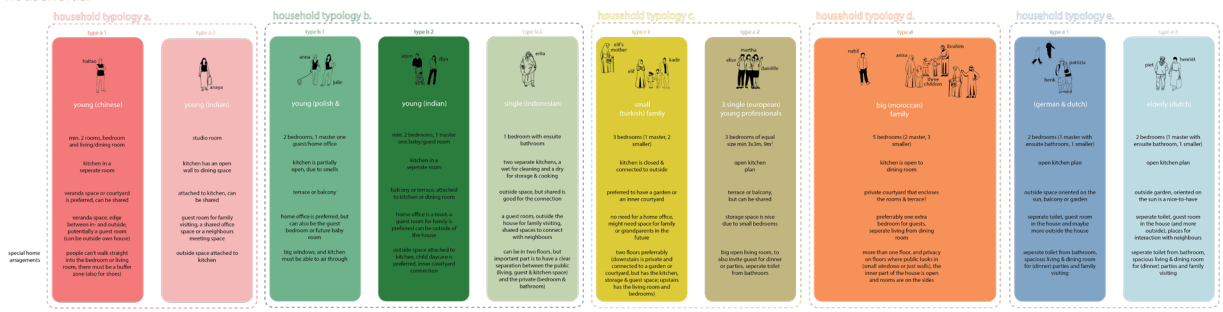
building.
scale 1:200.

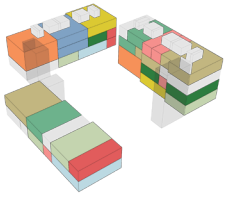


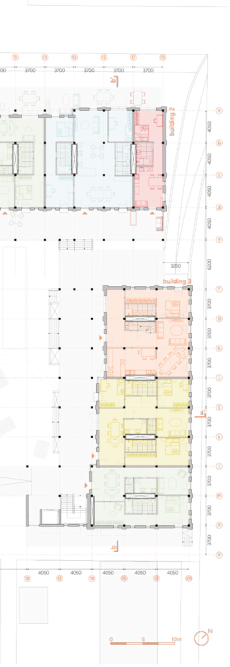
ground floor.



households.

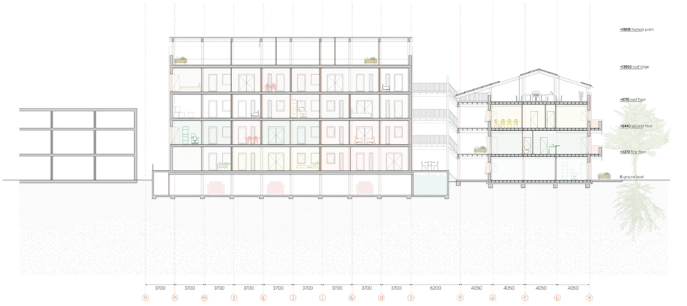




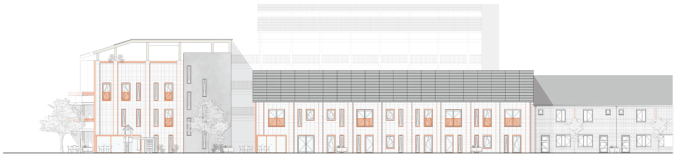




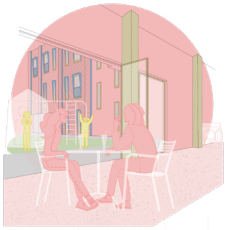
first floor.

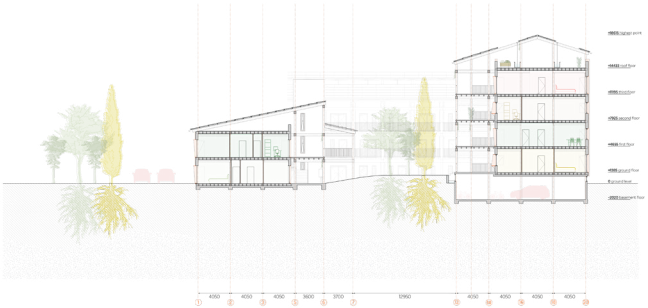


section bb'.

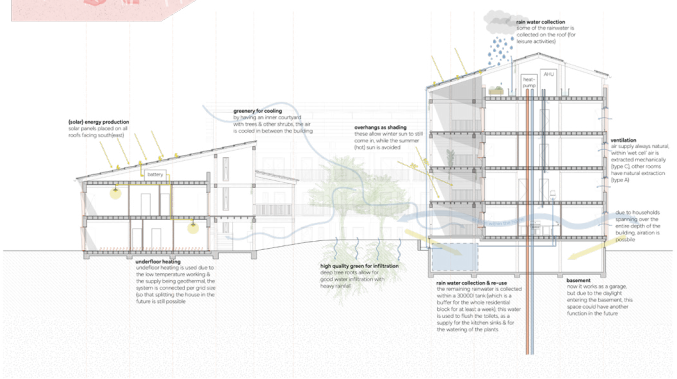


south-west façade.





section aa'.

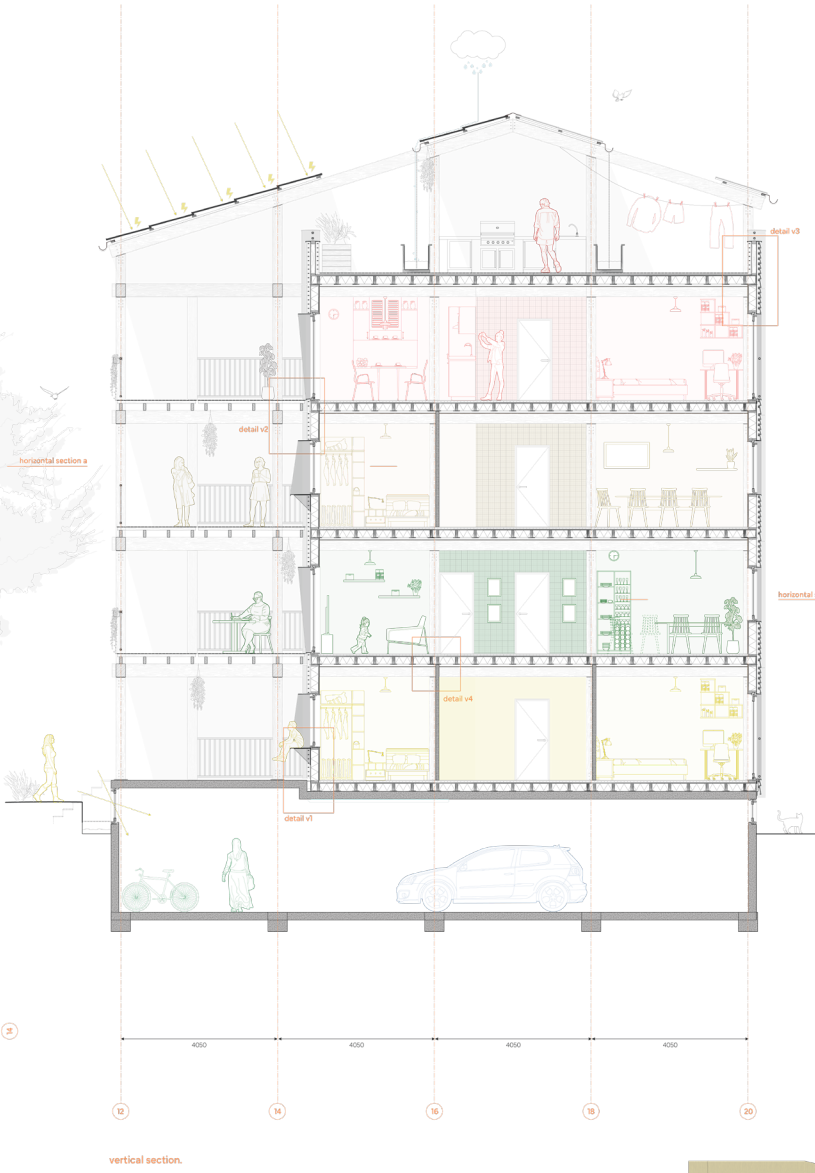


climate duagram.

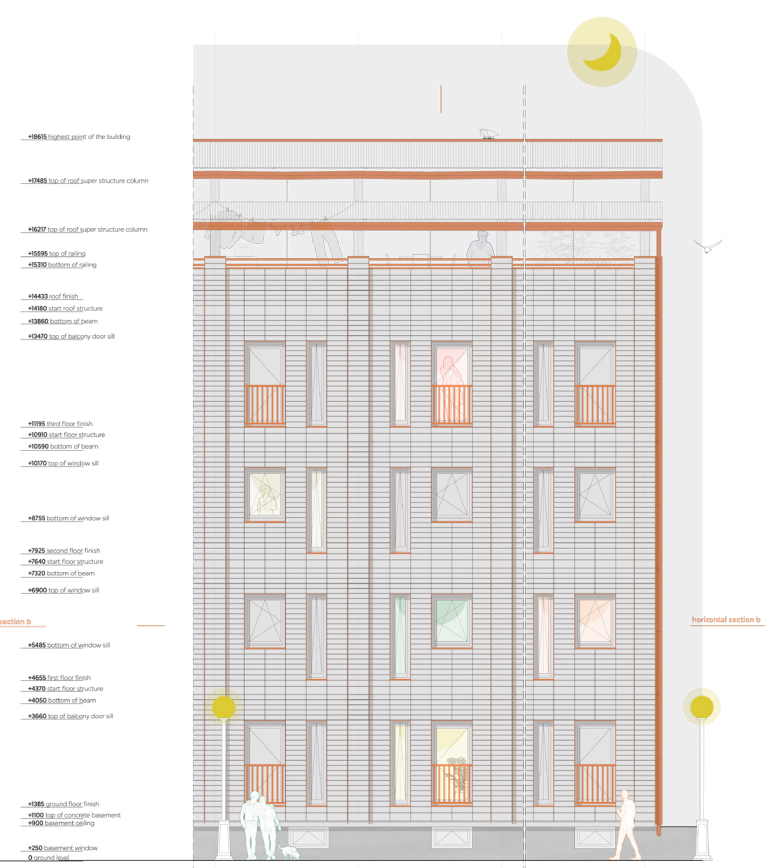
naterialisation.

:ale 1.50.



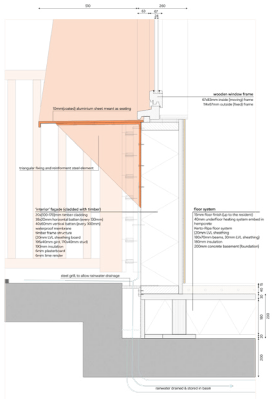




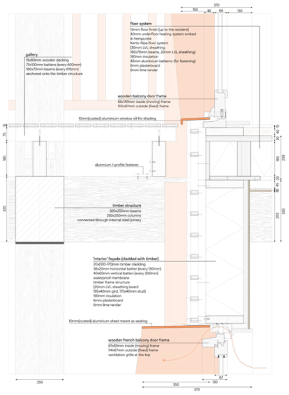


horizontal section b.

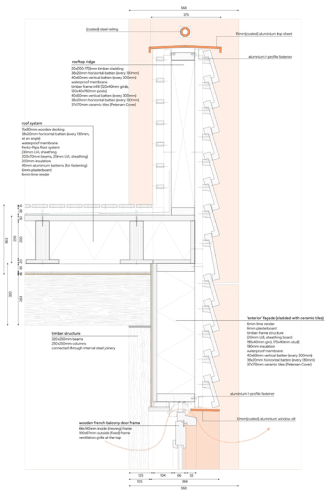




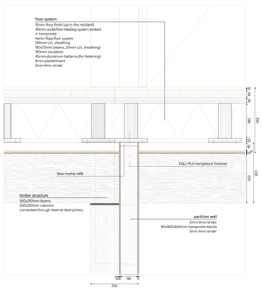
detail v1.
scale 1.10.



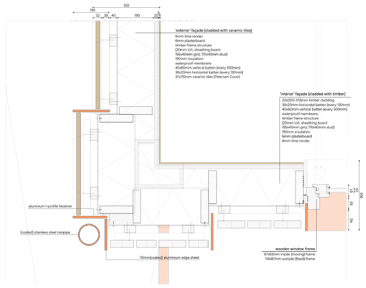
detail v2.
scale 1.10.



detail v3.
scale 1.10.



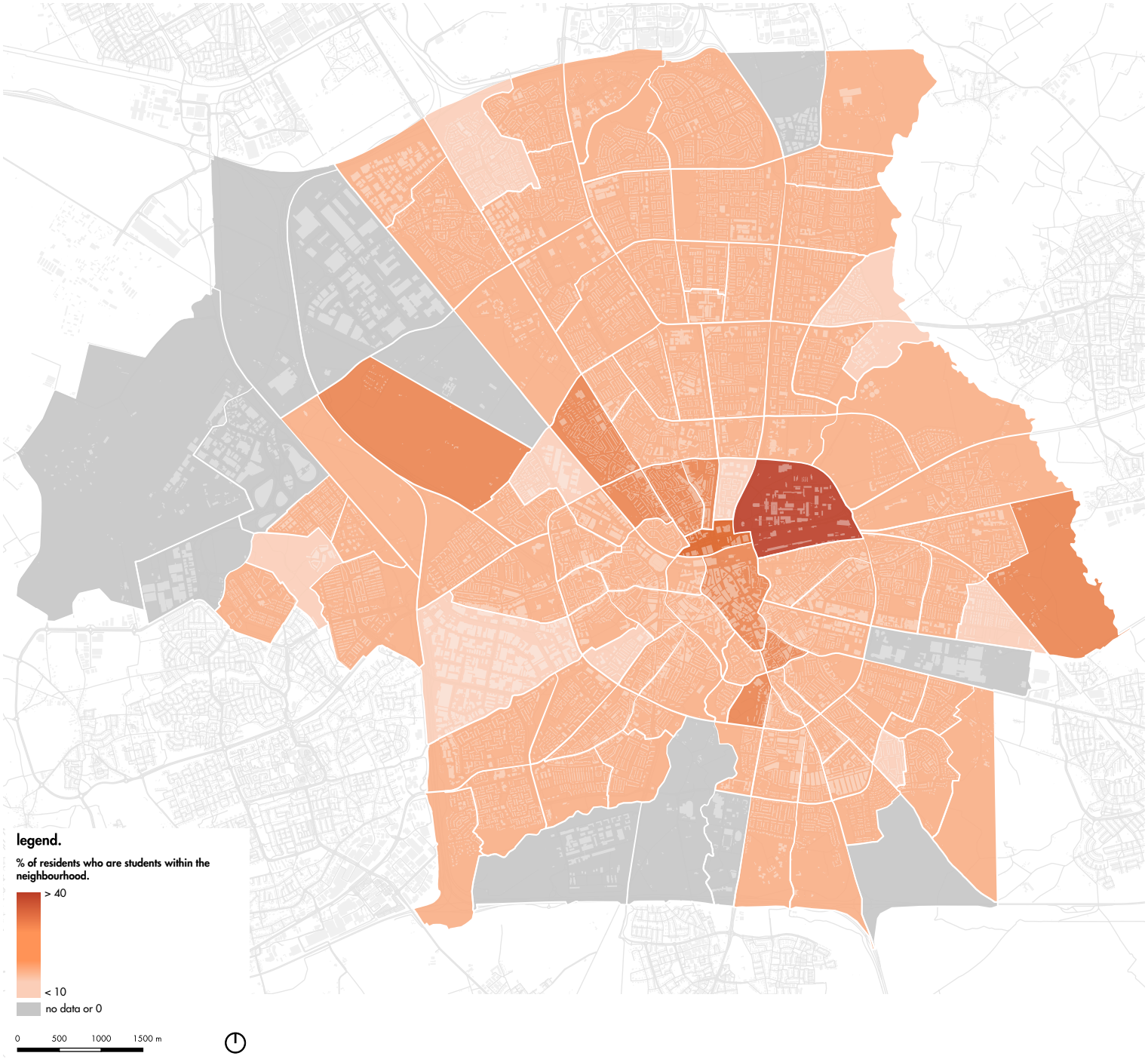
detail v4.
scale 1.10.

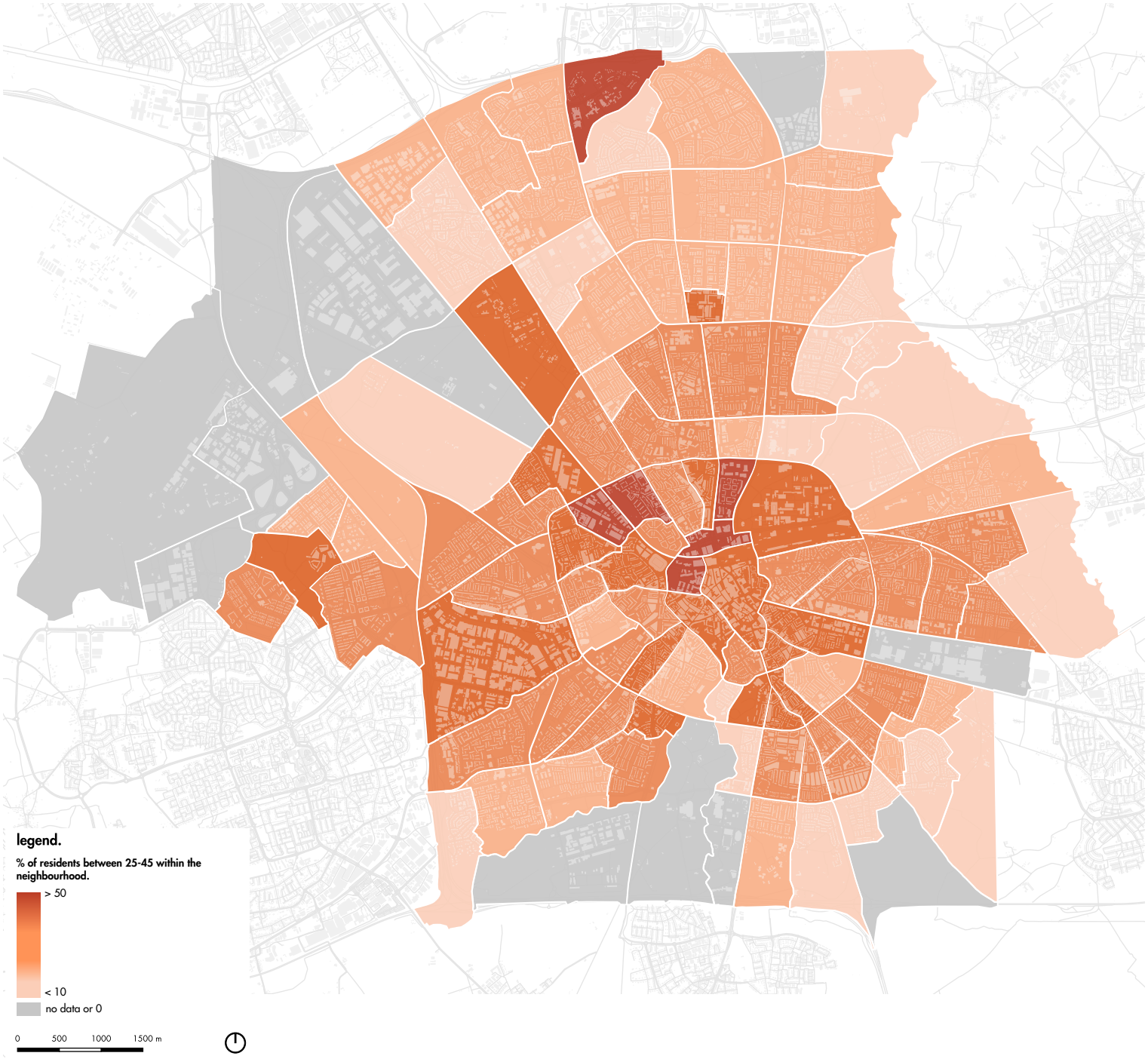


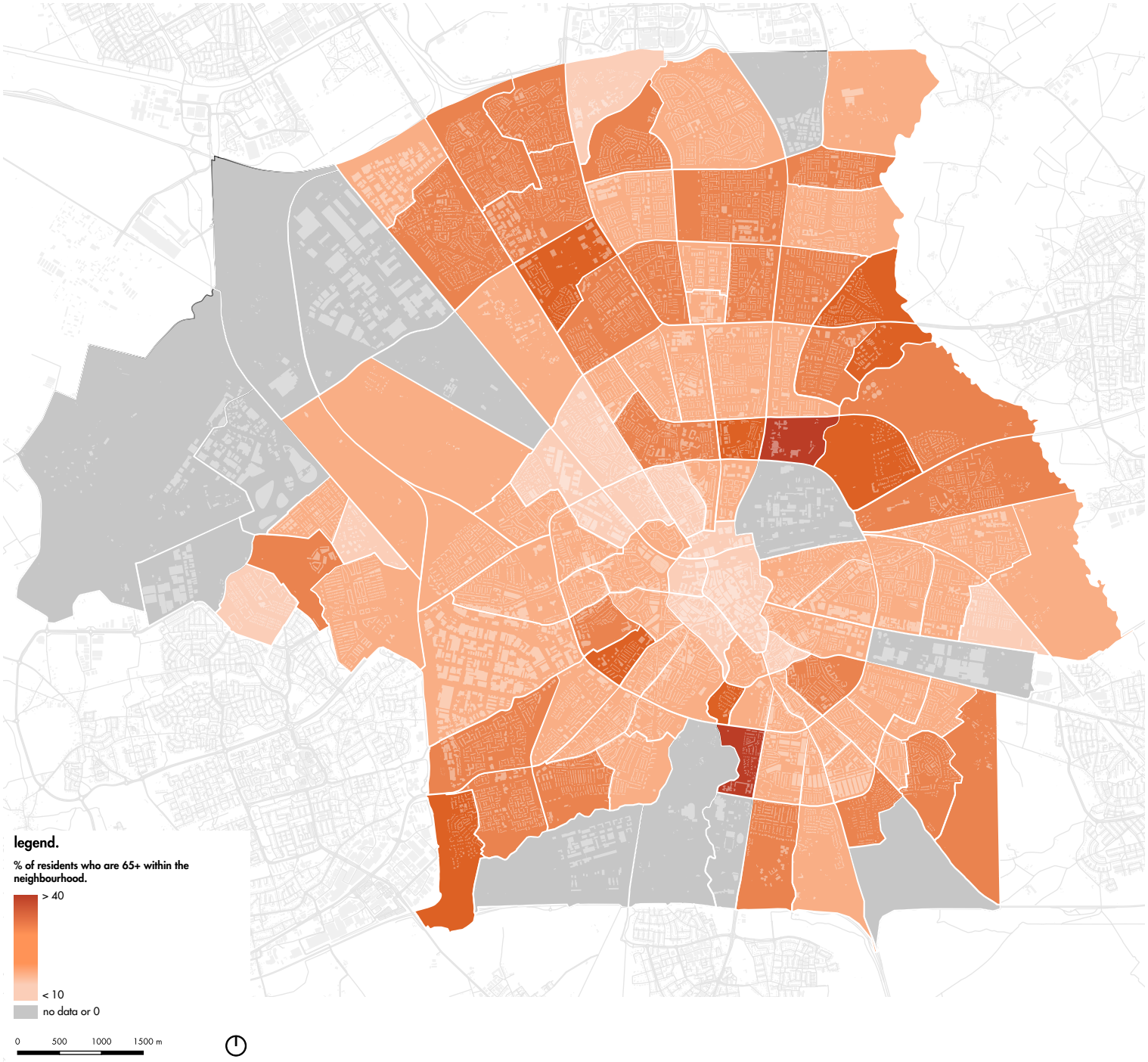
detail h1.
scale 1.10.

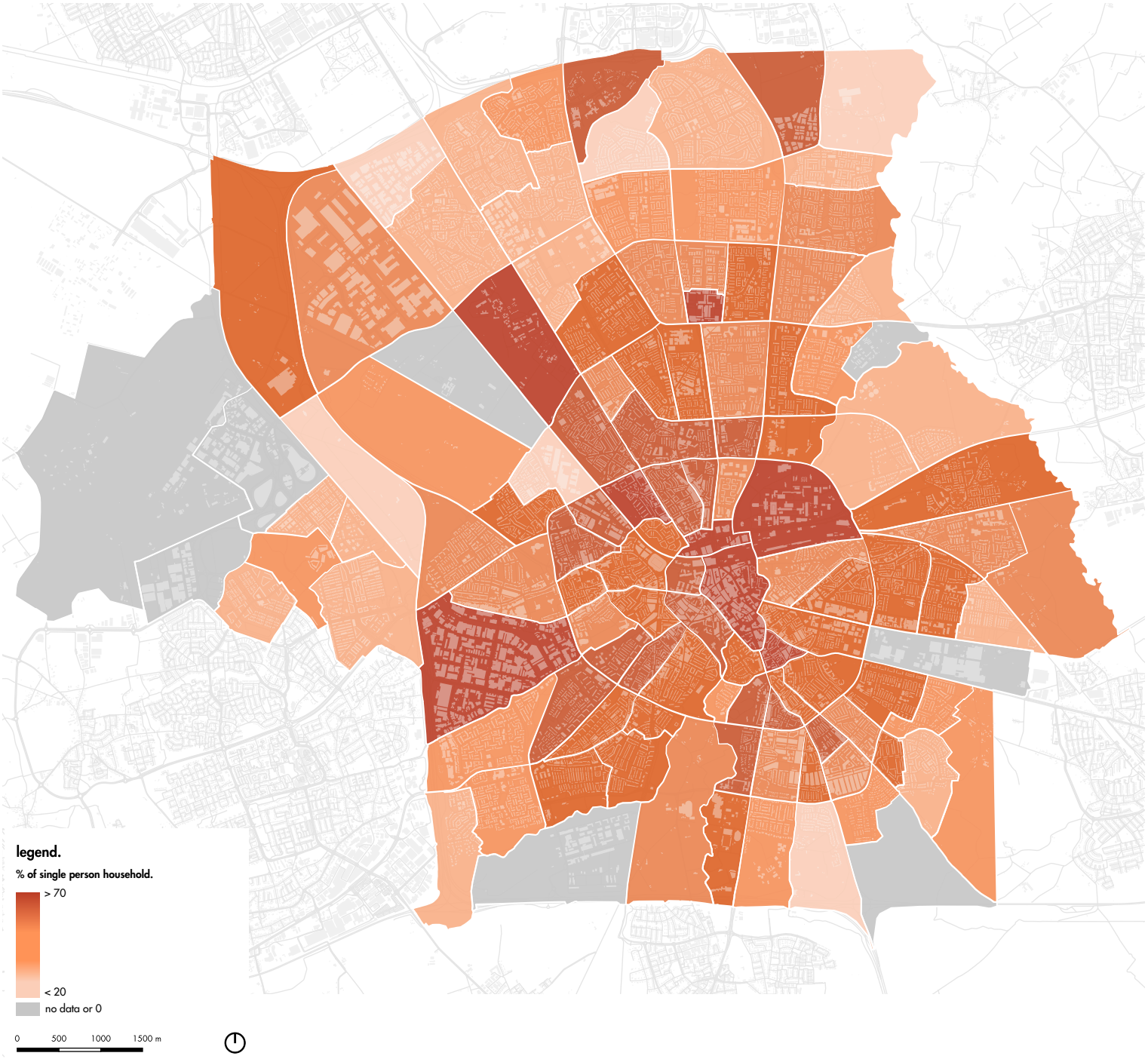
appendix g.

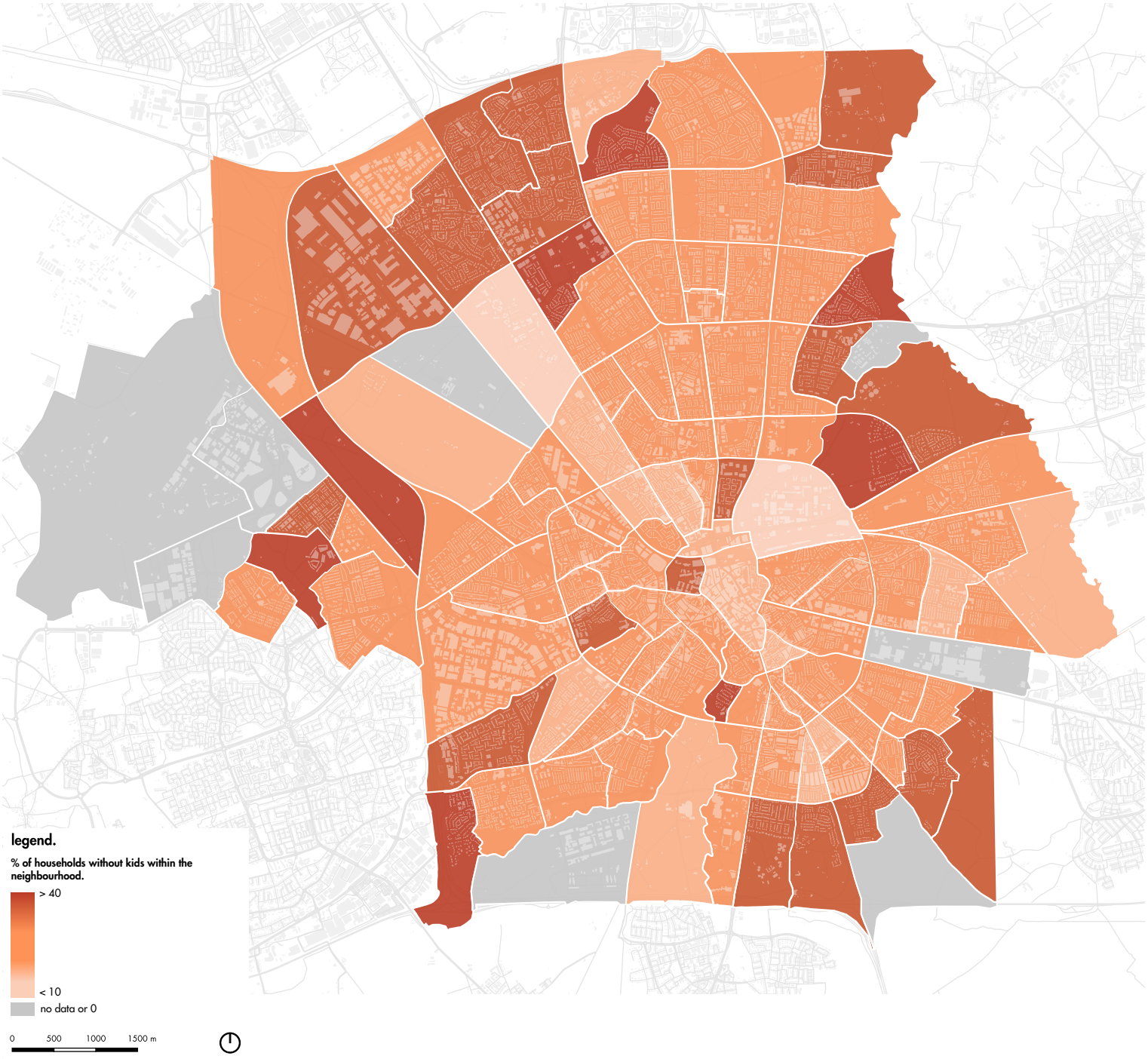
This appendix gathers demographic analyses of Eindhoven. These analyses were initially used to further support the site choice and its related contextual factors.


legend.
% of residents who are students within the neighbourhood.
> 40
< 10
no data or 0
0
500
1000
1500 m


legend.
% of residents between 25-45 within the neighbourhood.
> 50
< 10
no data or 0
0
500
1000
1500 m


legend.
% of residents who are 65+ within the neighbourhood.
> 40
< 10
no data or 0
0
500
1000
1500 m


legend.
% of single person household.
> 70
< 20
no data or 0
0
500
1000
1500 m


legend.
% of households without kids within the neighbourhood.
> 40
< 10
no data or 0
0
500
1000
1500 m

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