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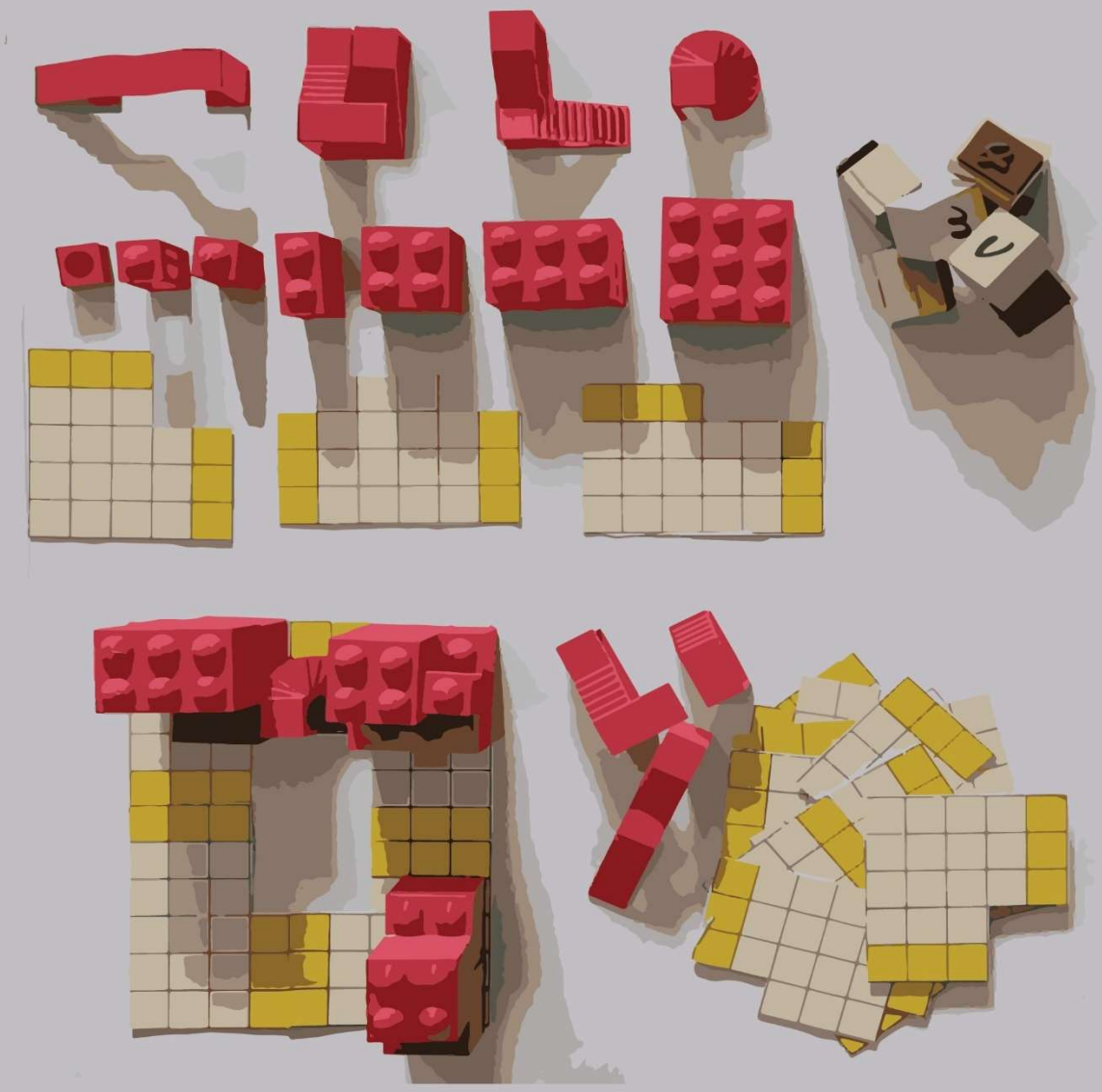

Participatory Design Game for urban slum upgrading in the Context of Addis Ababa

MSc Architecture, Urbanism and Building Sciences, TU Delft
Track: Building Technology

Bezawit Zerayacob Bekele | 4780914

Mentors: Dr. ir. Pirouz Nourian, Prof.ir. Dick van Gameren

Delegate of the Board of Examiners: Dr. Giorgio Agugiaro

In partial fulfillment of the requirements for the degree of

Master of Science

in Architecture, Urbanism and Building Sciences
at the Delft University of Technology

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Motivation for conducting the study

Before coming to TU Delft, I had developed an interest in vernacular architecture and sustainable urban slum upgrading strategies. During my studies, I developed an interest in computational design. Growing up in Addis Ababa, I witnessed the rapid urbanization and expansion of the city. My motivation for doing this research stems from the understanding of the disconnect between the need of low-income communities and available affordable housing solutions. Within these low-income communities, there is vast diversity yet a deep sense of community, mutual understanding, and collaboration. Urban ugrading and re-development strategies often neglect to give voice or space to low-income communities.These low-income communities reside in characteristically slum neighborhoods, where they rely on the locational advantage, social structure, and small-scale trade and exchange within the space they inhabit. These spatial values are threatened by the urban renewal strategies that don't allow room for end-user participation. By translating the general topic of gamification of generative design to my local context; I merged my interest in computational design with developing socially conscious slum upgrading solution by using serious games as a participatory tool engaging end-users in the design process in hopes of resonating the voice and spatial needs of low-income communities.

Acknowledgement

I would like to thank God for seeing me through to the finish line.

Completing this Master's thesis would not have been possible without the guidance and support of many. Although I may not mention everyone here by name, I would like to extend my gratitude to all those who have supported me throughout this journey.

First and foremost, I would like to thank both my mentors for dedicating their time to advise and impart their knowledge. I would like to thank Dr. ir. Pirouz Nourian for his enthusiasm from the very beginning till the end of my thesis. He not only advised my project but also helped me in times of self-doubt and uncertainty. He also encouraged me to envision my project outside the realm of the master's programme. I would like to thank Prof.ir. Dick van Gameren for signing on to be my mentor despite his busy schedule. He gave me various valuable resources and helped me narrow my scope, understand the limitations of my research and ground my 'dreamer' ideas.

I want to thank TU Delft's Global Initiative for investing in my education.

I want to thank my friends for encouraging and supporting me. I want to thank Anteneh for listening, advising and sharing resources with me. I especially want to thank my friend Maimuna for being my family away from home.

Lastly, I would like to thank my parents and my brother for their unconditional love and support.

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Acronyms and local terms

AACA Addis Ababa City Administration

AARH Agency for the Administration of Rental Housing

EDO Environmental Development Office

GHP Grand Housing Programme

IHDP Integrated Housing Development Program

KDC Kebele Development Committee

LDP Local development plan

MWUD ministry of works and urban development

NGO Non-Governmental Organization

Birr Ethiopian currency

Chereka bet Squatter house

Chika Mud and wood construction

Iddir Funeral and burial support association

Injera Ethiopian flat bread

Iqub Financial Association

Kebele The lowest administrative unit of cities

Mahiber Associations formed by mutual interests, also means cooperatives in some instances

Sefer Neighborhood

Woreda Administrative unit one level higher than kebele

CHAPTER I

1 CHAPTER I INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The research explores serious games as a participatory design methodology for upgrading slum neighborhoods and integrating user-generated spatial configurations for low-rise incremental developments in the context of Addis Ababa, Ethiopia. Below, games (serious) will be defined in relation to participation, where the significance of participation in architectural design will be discussed, followed by a brief introduction of the contextual setting.

Games have served as tools for research, design, teaching, and learning processes; the development of the games can be intended to serve a singular or a multimodal purpose. Clark C. Abt (1970) defined games as "*Reduced to its formal essence, a game is an activity among two or more independent decision-makers seeking to achieve their objectives in the same limiting context*". Here, several important aspects of games are mentioned; games involve multi-players engaged in decision-making towards meeting an objective in a given context. This research is focused on the potential of serious games involving the participation of end-users to meet a design objective by integrating user-generated spatial configurations in slum upgrading strategies in the context of Addis Ababa's neighborhoods, here on referred to as 'sefers'.

Lerner (2014) noted the ability of games to induce participation and collaborative design decision-making. Collaborative design games have been used as tools for engaging meaningful participation of multiple stakeholders, including users and designers, through defined game rules and game pieces. John Turner (1976) argued the importance of participation in-dwelling design, saying: *"When dwellers control the major decisions and are free to make their contribution to the design, construction or management of their housing, both the process and the environment produced stimulate individual and social well-being. When people have no control over, nor responsibility for key decisions in the housing process, on the other hand, dwelling environments may instead become a barrier to personal fulfilment and a burden on the economy".*

The significance of participation translates into the context of Addis Ababa, as the rapid urbanization of the city poses documented threat to existing socio-economic relations, social security, and income generation means for low-income dwellers of the city. These low-income characteristically slum neighborhoods not only serve for dwelling purposes but incorporate multi-dimensional social and economic interdependences within the community. The characteristical slum neighborhoods are enclaves where small-scale production and trade occur(Gameren & Mota, 2020). The residing community is netted with social networks and financial associations. As the number of the city's residents continues to increase combined with the city's rapid urbanisation, these multi-purpose enclaves face the challenge of being replaced by dense urban forms. As part of the solution, Addis Ababa's city administration has proposed standardized affordable housing solutions that often require low-income households to relocate and adapt to generic spatial configurations rather than developing housing solutions that are responsive to the livelihood of the existing community. The research focuses on developing a meta-game for co-designing courtyard-based communal dwellings using pre-defined modules representing spatial volumes that end-users can use to layout their preferred spatial configuration following a set of game rules that determine the validity of the user-generated design. The meta-game can simulate how to upgrade existing kebele compound houses or propose low-rise incremental communal dwelling units as slum upgrading strategies. The game allows end-users to participate in the design decision-making process. The context will dictate the game elements, rules, and play process. The game and the play process will be demonstrated by using a test case. The outcome will be evaluated and presented followed by findings and recommendations for further studies and application.

1.2 PROBLEM STATEMENT

The community residing in the slum areas of Addis Ababa have strong socio-economic and spatial ties with the space they inhabit. While there is a need for densification and the introduction of affordable housing solutions, it has become essential to ***develop participatory design methodologies*** *that* ***preserve*** *and perhaps enhance the* ***socio-economic values*** *embedded within the* ***spatial configuration*** *of the* ***existing community****.*

The neighborhoods or 'sefer' within Addis Ababa result from historical events, planned interventions, and self- actualizations by the community(Gameren & Mota, 2020). Due to the high influx of people from rural areas to the capital city, the city suffers from a huge affordable housing deficit. The city dwellers adapted to this demand by incremental developments resulting in informal settlements and neighborhoods characterized as slums. To curb the increasing affordable housing demand, the government adopted the integrated housing development program. The housing strategy involves relocating urban slum residents to new developments in the outskirts of the city. Although these urban renewal projects were somewhat effective in curbing the housing demand, the projects are criticized for failing to consider the socio-economic and spatial values embedded within the existing community. As many characteristically slum neighborhoods of Addis Ababa serve a multi-purpose, where domestic production and small-scale trade and exchange occur, it is also arguable that the relocation to re-developments puts a strain on the livelihood and self-sustenance of these communities. Ynitso (2008) wrote, "The process of relocating people from the inner city to new resettlement sites in the outskirts have disrupted the relocatees' business ties with customers, broken their informal networks of survival, caused loss of locational advantage and jobs and incurred high transport costs." According to a study conducted by Abebe & Hesselberg (2015), although the relocation procedure ought to have followed a human-centered approach, there was no genuine community participation or study of the relocated groups and the resulting changes to their livelihood. For the aforementioned reasons, a different approach for upgrading slum areas of the city is required. End-users should be involved in the design decision-making process without their needs being subdued by other stakeholders.

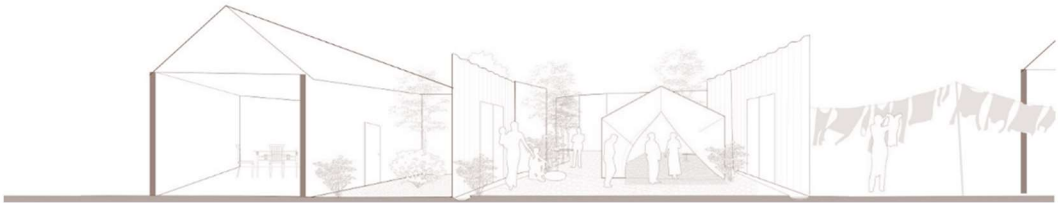

Figure 1: low-income compound. https://repository.tudelft.nl/islandora/object/uuid:c1827ab8-9e8d-4444-a1c9-6822f1758617/datastream/OBJ/download

Figure 2: Activities in slum dwellings. https://tudelft.openresearch.net/image/2016/9/12/presentation_pinar_07_09.pdf

Brandt (2006) argued most participatory design games are exploratory activities for staging horizontal or equal participation, where interaction among players is guided by critical reflection or a clearly articulated set of game rules implemented with tangible game pieces. This research explores the potential of using a

participatory game aimed at spatial configuration and design of low-rise courtyard-based dwellings that can be used for slum upgrading developments in the context of Addis Ababa.

1.3 RESEARCH QUESTIONS

The study's main research question is, how can end-users co-create valid designs using *pre-defined* ***modules***, ***simple configuration guides/rules,*** *and a sequence of* ***stakeholder inputs****?*

1.3.1 Design questions

- How should the pre-defined modules be designed with respect to existing/required proportion and scale of programmatic functions?
- How should the incremental configuration guides/rules be developed in relation to existing spatial patterns and boundaries?
- How and in what sequence should the stakeholders take part in the design decision-making process?

1.4 RESEARCH OBJECTIVE

The research objective is to enable end-users to actively participate in the spatial configuration and design decision-making process of their immediate environment by using a participatory game. The game will allow users to co-design a courtyard-based communal dwelling using a set of defined modules (or playsets), and a sequence of stakeholder inputs while following a configuration guide (or game rules) derived from studies of the multi-layer structure and complexities of the slum neighborhoods of Addis Ababa.

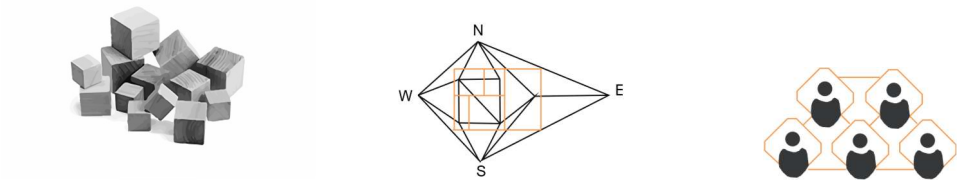

Figure 3: Modules, configuration rules, and sequence of play.

1.5 RESEARCH METHODOLOGY

Research Methodology (define game development through literature review- design – demonstrate play using a test case – evaluate)

The research methodology is conducted as research by design, where a theoretical framework is developed through a literature review that informs the game design and development, followed by a demo of the developed game using a test case and visualization of the results.

1. Literature review

   The literature review is divided into two parts; the first part discusses theories about serious games as participatory design tools and explores studies of the application in collaborative design. Here collaborative design is explored and theories about how rule-based systems can be developed based on the studies

of spatial morphology and principles of modular coordination systems and open building concept are discussed. Understanding the type and level of participation, game mechanics, game components and rule-based configuration systems inform the design development stage of the research.

The second part of the literature review discusses the context, where studies of the spatial morphology and socio-economic construct of Addis Ababa's slum neighborhoods will be presented. Patterns of habitation within kebele compounds are presented. Furthermore, the existing slum redevelopment strategy and affordable housing policy are briefly discussed. The contextual study is then used to define the design brief and inform the design development of the game components.

2. Design Development

In the design development stage, the serious game components are designed based on the defined theoretical framework and the contextual study. Here the modules, modular units, and configuration rules will be designed and defined based on the studied spatial morphology, principles of modular coordination, open building concept, game theory, and contextual study. The sequence of stakeholder inputs and the play process will be outlined in the game rules.

3. Demonstrating and Validating

The developed serious game will be demonstrated using a test case. The play process and output are documented. The results will be discussed and recommendations will be posed for further study.

1.6 SCOPE AND LIMITATIONS

The scope of the study is multidisciplinary crossing in-between architecture, computational design, and game design.

The study relies on past researches, studies, and the researcher's lived experience to understand the context. Due to the inability to gain access to conduct on-site visits to multiple kebele compounds, the game will be demonstrated using one test case. While the research focuses on participatory architecture, it may fall short in considering all the different aspects of low-cost housing. The research does not delve into a deep exploration of constructability in the gameplay demonstration. And the research doesn't go into quantifying costs and discussions of affordability.

1.7 RELEVANCE OF THE STUDY

Affordable housing is a challenging subject to tackle; many aspects need to be considered to propose a viable solution. Matters of land, tenure, cost, population growth, available building materials, city development plans are some factors considered when proposing housing solutions. But matters of locational advantage, patterns of habitation, means of livelihood, priorities of spatial configuration, growth of household size and incremental development are aspects that are equally important and should be considered when thinking about proposing housing solutions for low-income dwellers. Doing so will require extensive research and derivation of new housing policies. Through this research, I am exploring a methodology of design that utilizes game mechanics. By using a set of modules and a rule-based system, the dwellers can generate designs that respect their spatial values, patterns of habitation, and allow them to think and design incrementally. The scientific relevance of the research is the development of a design methodology that respects social complexities with the use of scientific methods like graph theory and game design theories.

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CHAPTER II

2 CHAPTER 2

2.1 PARTICIPATION IN ARCHITECTURAL DESIGN

Participation is used as a democratic process of making decisions by allowing various stakeholders to exchange information and resolve conflicts. Participation can happen in various forms, these are mainly determined by the type, the level, the frequency, and the method used. Participatory programs provide a means of cooperation between various groups including government and non-government bodies, professional experts, and community groups, which may have competing interests. These programs also provide effective ways to collect and analyze information.

. Participation happens at different levels, identifying which actors contribute to which levels of the design process can help to organize stages of participation according to the project.

To create a well-structured participatory system the following should be defined

1. Participants: People affected by the planning and design decisions should be involved.
2. The objective of each participatory level: Identifying the objective of the process, this can be, consensus building, feasibility, program design, negotiation, proposal review, gathering information, design formulation, etc.
3. Form of participation: nominal, consultative, instrumental, representative, or transformative.
4. Scope of participation: development, implementation, evaluation...etc

The product of participation may not signify the end of the process, the process can be continuous that can be re-evaluated and adapted as needed.

The effectiveness of a participatory process depends on the objectives and the method of participation employed. Participation in architecture can be used to inform and supplement design and planning. Individuals and groups that are affected in the planning and design decisions should be engaged in the participation process. The process should be easily communicable, open, and clear. This ensures that end-users can be involved in the design decision-making that will enrich the quality and direction of their lives. Participation can bring people with the same goals and values together creating a sense of community. It is a means of direct public engagement therefore it requires suitable grounds for end-user participation in design. This in turn increases that capacity of meeting social needs and utilizing resources effectively. By creating a methodological framework that allows users to make rational decisions without blocking their creativity is needed in the design. In this case, the professional acts as a facilitator in the development of user-generated solutions rather than producing finished and unchangeable results.

2.1.1 Participation in housing

According to John Turner, the social well-being of dwellers is correlated to the level of control they have in the design, construction, and management of their housing (Turner, 1976). In the developments of mass housing, an approach of what is considered good design is employed based upon stereotypical assumptions where housing needs are reduced to standards and building codes that subsequently discount public participation and the part of the dweller in the design process.

Sanoff argues that housing solutions only adhering to static formulas, and fixed notions based on theories of housing development and ideological commitments rooted in the western industry are not necessarily appropriate in most societies where the house is beyond a physical structure(Henry Sanoff, 1988). Housing is a complex subject that encompasses cultural, physical, social, and material aspects as well as customs and habits of a community. Participation in housing needs to be contextual. In subsidized mass housing and affordable housing constructions, the design of the housing units is designed to be standards for an average family of a given set of household sizes. Households that are different in their socio-cultural needs are forced to adapt to housing units designed to accommodate the needs of an average family. John turner argues that housing problems should be defined to include a mismatch of a housing function to people's socio-economic and cultural needs as opposed to just unmet housing demand (Turner, 1976). A large portion of the world's housing is constructed outside the official institutional framework resulting in solutions that are contextual, viable, and reflective of the socio-cultural needs and economical capacity of the community. This is why self-help houses are more responsive to user's needs and are attainable within the user's income capacity. Self-help housing is based on realistic requirements and costs where the poor can gradually build and improve their housing where income-generating functions are integrated into the physical and social infrastructure to meet their socio-economic needs(Haysom, 1996).

In the book housing without houses, Nabel Hamdi defined two paradigms, namely providers and supports (Hamdi, 1995). The provider paradigm is characterized as a system of curbing housing demand and improving the quality of habitable spaces is controlled by public authorities. The support paradigm is characterized by a partnership between the public authorities and the community.

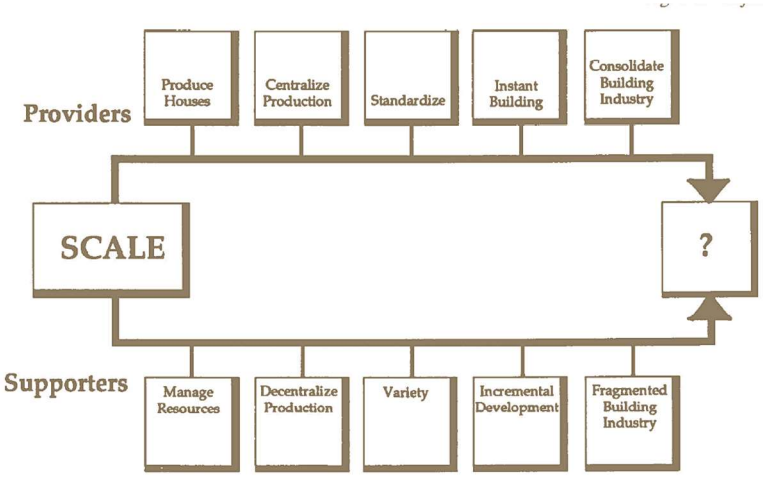

Figure 4: Supporters and providers. From: Housing without housing (p.27), by Savag Pogharian ,1995

Development opportunities and urbanization with a critical demand for adequate housing need a sustainable approach that is appropriate and participatory of all stakeholders, in particular the vulnerable and disadvantaged ones (Haysom, 1996).

Theories of Practice: Key Characteristics

Providing	*Supporting*
Objectives	
Build houses for people	Allocate resources for people to organize their own house building
Use house building to fuel economy	Use the economy to fuel house building
Centralize resources to facilitate management and control standards	Decentralize resources to support local enterprise and home building
Build organizations that facilitate central initiatives	Build regulations to support and give structure to local initiatives
Consolidate and centralize building production	Fragment building production and support small builders
Sectoralize development activities for ease of management, single-function projects	Integrate development activities and link housing to larger urban systems of employment and production
Methods	
Build large projects to achieve scale	Build programs and allocate resources for many small projects
Manufacture housing to speed production	Manage resources to increase volume
Build fast by building instantly	Build fast by building incrementally
Standardize project and operations	Promote variety, improvisation, infill, sites, and services
Clearance and redevelopment	
Tell what to do	Tell how to find out what to do, then how to find out how to do it
Products/Component	
Projects	Interventions
Behaviorally deterministic planning	Technical aid centers
Industrialized building systems	Training
Master plan	Housing options and loan packages
	Guidebooks, guidelines, tools, and methods
	Appropriate technologies
	Structure plans
Key Actors	
Consultants	Families
Government agencies	Community groups, tenant organizations, nongovernmental organizations
Funders	Nonprofit and voluntary organizations
Large contractors/developers	Government agencies
	Small contractors
	Funders
	Formal and informal private community developers
	Consultants

Figure 5: Theories of practice, Key Characteristics. From: Housing without houses (p.29), 1995

While addressing slum upgrading, Ivo Imparato and Jeff Ruster (2003) defined participation as a process whereby people and primary underprivileged people can direct the provision of resources, formulation, and implementation of policies at different levels of development stages.

Participation in housing involves giving more control to communities and local organizations yet a process of enablement is required to allow people to exercise control of the decision-making process. Once the users understand the design decisions to be made, the user can generate their own designs that are more responsive to their needs rather than merely reacting to alternatives provided to them. This design process

is not static, it can be re-adapted to the changing needs of the users by the users themselves. The degree of participation of users is dependent on the available social tools of designing, the flexibility and receptiveness of the planning system, and the adaptation of appropriate techniques. The participatory design method must be organized in a way that allows non-professionals to actively take part in the planning, designing, and construction of their houses and neighborhoods. The creation of a system involving standardized parts that can be configured in various ways following procedures that guide people in the design process, methods of construction, and engagement of the architects as facilitators can be useful in achieving the enablement aspect of participation to solve housing problems.

2.1.2 Levels of participation

Deshler and Sock (1985, in Sanoff, 2000), identified two stages of participation. These are pseudo-participation and genuine participation. Pseudo-participation is where the control of the project lies with the administrators. In this case, the people are presented with what is planned for them. Genuine participation is where people are empowered to take action and make decisions.

Participation in housing can occur at various levels and types. According to Sanoff (2000), the stages of participation can briefly be categorized into four levels. The first of these being, goal setting. In this stage, the participants are defining areas for change based on the realities of the current state of their given environment. The next stage is the programming stage where the participants form an understanding of the context, the physical, socio-economic and cultural objectives, and resources. The next level is designing where the participants make/propose physical designs based on their priorities. The final level of participation is implementation, where users are engaged in the implementation of their proposed design.

2.1.3 Challenges of participation

Various factors affect participation; among these are time, capacity, miscommunication, and urban bias. Public participation is assumed to be inefficient due to time consumption as well as assumptions that people don't know what they want therefore it's concluded that experts know better about the user's needs. In design and planning, creating an environment where non-professional can effectively take part in the design decision-making without being overshadowed by expert opinion is a challenge. If the framework of housing design and the delivery mechanism doesn't incorporate citizens and housing policies are not well organized, it can hinder participation.

2.1.4 Importance of participation

Participation in housing is necessary to understand the socio-economic fabric of the dwellers. It allows the reflection of user needs and values, it is a pluralistic and inclusive approach. It allows elements of culture, socio-economic interdependence, and locational advantage that create the living environment of a community. Participation allows for democratic decision-making in the planning and design process. It empowers the community to have control by enabling them to make decisions based on their priority related to their lifestyle, socio-economic and physical conditions.

2.2 PARTICIPATION GAMES

Participatory games give structure and define a process for collective decision-making. This usually involves abstracting real-time situations or problems where the essential components of a given problem can be examined and simulated to provide a solution/ decision. The arrival at a solution or decision follows methods and procedures outlined by the game setting and the game rule system followed by the players in the prescribed setting. Such games are categorized as serious games.

There is no one universally accepted definition of the term serious gaming. Michael and Chen (2006) explain serious games as not having entertainment and fun as the primary purpose. The application of serious games is varied; it can be used for the development of conflict resolution strategies and elevation of civic engagement. Serious games with good gameplay can foster active engagement, quick learning, and immediate feedback and adaptability(Dörner et al., 2016).

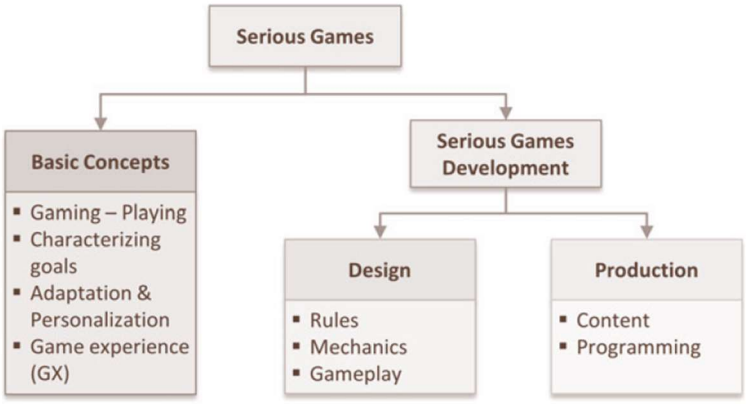

Figure 6: Serious games framework. From: Serious games (p.7), 2016

The development of serious games has two main components: these are the game design which incorporates the inner structure and outer appearance of the game. The game production involves all facets of structuring the game (Dörner et al., 2016).

2.2.1 Aspects of game design

There are three aspects to the game design, these are game mechanics, gameplay, and game rules. Game Mechanics: Is the way players interact with the game and organization of inner interactions. Gameplay is the sequence of actions in the play process. Rules define the regulation and setting of the game, it usually consists of action-reaction conditions.

Vaajakallio (2012), expresses design games as an engaging medium for ideating designs using game visuals and incorporating game rules, a player turns, role-playing similar to that of in board games. Using a familiar game format creates a common framework for participatory guidelines allowing participants to elicit their needs, arrive at a mutual agreement, and envision new solutions. Visual elements like artifacts and tangible props can be used to facilitate collaborative design or "design by playing"(Björgvinsson et al., 2012).

2.2.2 Gamification in architecture

Gamification is the process of adding game mechanics to a non-game context. It provides a means of collaboration and involvement in strategy to engage users in solving problems. Sanoff (1979) argues that games can also be used for consensus building in addition to simulating situations and design decisions made. Through participating in the design game, the players gain a better understanding of the design problem and express their values in the design action. The decision-making process in the game setting helps players align their individual goals to the collective program and form complex configurations.

Sanoff explains the application of design games in housing as an effective way to engage and organize group decision-making and generating complex designs(Henry Sanoff, 2000). The games have a communal and social emphasis. One such game developed by Sanoff is the "housing trade-offs" game. The game has a basic grid layout and various graphic symbols that represent domestic activities/ space functions that players use in a collective play session. In the game, the players are allocated a budget that leads them to compare various alternatives and make trade-offs. In the process, the players identify their individual needs. The game results in a preliminary spatial organization that shows the key activities in relation to each other. This gives the players the chance to propose a housing layout that reflects their personal preferences. Such games can be used to attain various objectives related to housing layout based on social and physical preferences, including proposals of new housing alternatives that do not resemble conventional housing design.

Sanoff formulated a set of steps/considerations to follow while designing a design game.
- Define the problem to be simulated.
- Define the objective and scope of the simulation.
- Define the stakeholders involved.
- Define the motives and purposes of the participants.
- Define the resources available to the participants.
- Determine the actions and rules to be followed.
- Formulate the validation method.
- Develop the prototype.
- Test and modify the prototype.

2.3 OPEN BUILDING CONCEPT AND MODULARITY

The open building concept was widely introduced by John Habraken. It is the idea of introducing bottom-up design into the traditional top-down design method. The open building concept allows for different stakeholders to make decisions throughout the design and construction process of buildings. The method of design separates the internal spatial organization from the service and utility of the building. The use of the open building concept in housing design allows households to make decisions based on their preferences and budget.

2.3.1 Concepts of open building design in dwellings

Throughout the different phases of design and construction, various individuals, groups, and organizations take control of the decision-making. These phases can be chatagorized in three different levles of decision-

making: these are tissue level, the support level, and the infill level. While these levels are separate, they are also dependent on each other.

Support: The support contains the shared facilities, these may be entrances, building structures, staircases, corridors, and the like. The support is designed in consideration of several factors including climate, building code, local means of design, and construction. The support allows the creation of a variety of layouts by accommodating changes made to the infill by the occupant while being independent. It allows the occupants to make their dwelling with limited constraints. Stephan Kendal and Jonathan Teicher (2000) wrote " Supports must be designed without knowing which particular infill products or systems will be employed, just as infill systems must be developed without knowing where they will be installed". The design of the support requires several stakeholders to make step-wise decisions together. Participants must agree on the standards and quality levels.

Infill: The infill is composed of elements that make a habitable space within a building, these may include partitions, doors, fixtures, and the like.

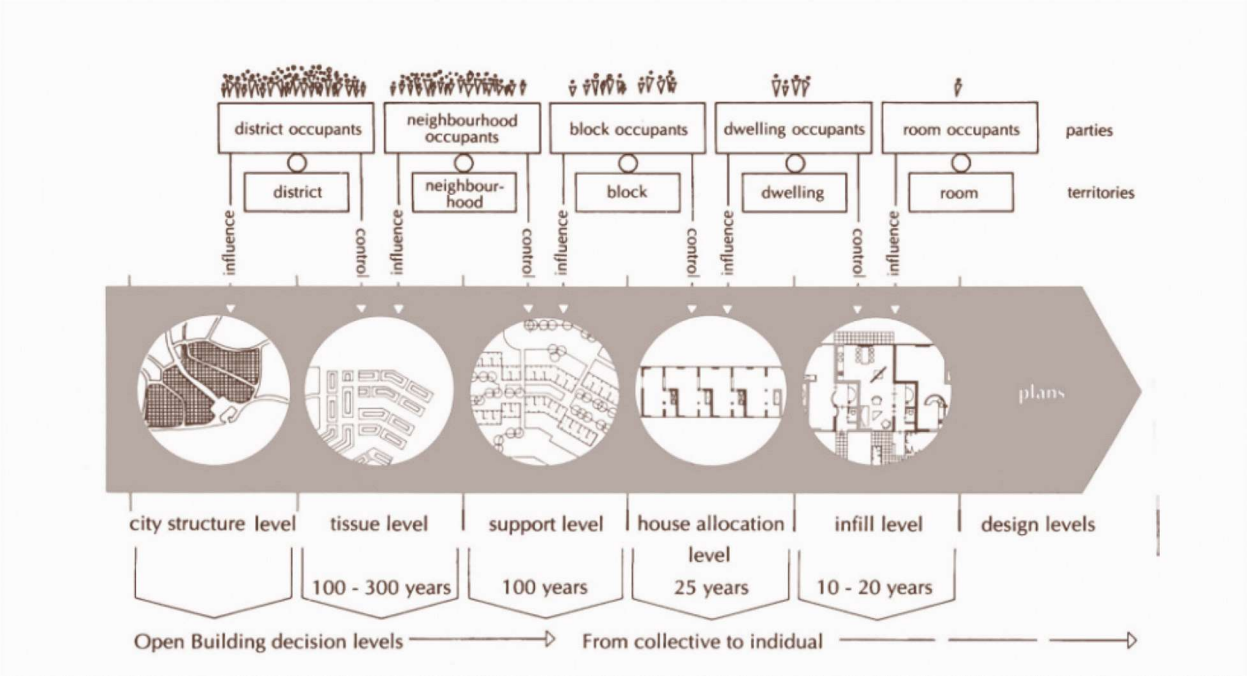

Figure 7: Decision-making levels in housing design. From: Open building, by John Habraken, 1961

When using open building design concepts in housing design, there are three distinct recognized participatory levels. These are the tissue level, the support level, and the infill level. For the design decisions made at these three different levels to become coherent and compatible, there must be a modular coordination system.

2.3.2 Modular coordination system

Modular coordination is a system based on dimensional rules that coordinate spaces and zones for placing building elements. The system includes a referencing system (usually a grid), rules for determining sizes of building components, and their coordination within the referencing system. The system allows free choice of the construction system, and freedom in architectural planning with the incorporation of standard

modules(Farhana et al., 2015). Grids are used as a continuous referencing system. A tartan grid system has bands that are regularly spaced and have a different modular order than the general modular planning grid.

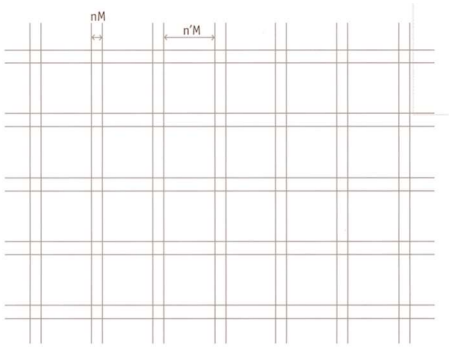

Figure 8: Tartan grid. From Modular coordination, BCA buildability series

The modular coordination also incorporates the vertical planning aspect where the main controlling factor is the story height (floor to floor height), and the intermediate controlling dimension is the door and window height. This coordination system co-relates the referencing system/planning grid with the building elements and components and at the lowest level with the finishes and built-in equipment.

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CHAPTER III

3 CHAPTER 3 – CONTEXT INTRODUCTION

3.1 ADDIS ABABA' S CHARACTERISTICALLY SLUM NEIGHBORHOODS

Characteristically slum neighborhoods have been part of the genesis and development of Addis Ababa. Before the proclamation in the 1970' s that made land public property; Property owners in the city of Addis Ababa sub-divided their plots and constructed rental houses without permits to meet the housing demand, Following the proclamation, the rental houses both formal and informal were nationalized and publicly owned. In the 1980s a different type of informal settlements came about in expansion areas of the city where squatter houses locally referred to as 'cheka bet' were constructed. This research focuses on the inner-city slum housing that has evolved throughout the years beginning the development of Addis Ababa as a garrison town. These houses are mainly government-owned since the proclamation, they are commonly referred to as kebele houses, and administered by the kebele (kebele is the lowest tier of the city administration established to subdivide and restructure the city).

There are 99 kebeles sub-divided within 10 sub-cities in Addis Ababa (Elias Yitbarek, 2008). In a census conducted in 2007, it was determined that 24% of the housing stock is kebele owned. Out of these, 70% are located in the Inner-city (Abnet Gezahegn et al., n.d.). The kebele houses are rented out at subsidized rates (below 100 Ethiopian birr per month, approximately 2 euros according to the exchange rate in 2020). Most of these houses are single-unit rooms encompassed in compounds with shared facilities including courtyard space, kitchen, and toilets. In some cases, tenants informally expand their houses to accommodate the increase in family size or as a means of income-generating activity. Kebele houses exhibit poor living conditions and are visibly deteriorating. The reasons behind this is the inability of the Kebele to maintain the houses due to the highly subsidized rent and the 1986 proclamation that prohibited upgrading of houses without foundation (Elias Yitbarek, 2008).

Name of Sub city	No. of *kebele* houses
Lideta	23,532
Kirkos	21,668
Arada	23,398
Addis Ketema	21,579
Kolfe-Keranio	6,715
Gulele	15,841
Yeka	10,459
Bole	3,539
Nefas silk-Lafto	4,130
Akaki-Kality	5,469
Total	136,330

Table 1: Number of Kebele houses per sub-city in Addis Ababa. From: AACA'S Housing Agency document (January – March 2003).

3.2 PATTERNS OF HABITATION: SPACES AND ACTIVITIES IN KEBELE HOUSES

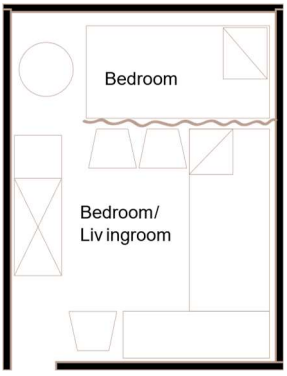
In most kebele-owned houses, several households live in a compound with a shared courtyard space. The courtyard spaces are used as an extension of the houses where several activities take place both domestic and commercial. Apart from the courtyard, the households often share kitchens and bathrooms. The shared use of these spaces creates various types of interdependencies between the different households.

Figure 9: Inhabitants of kebele house washing clothes in courtyard space. From: Source: Ongoing Ph.D. research by Anteneh Tola, by Author, (referred 2021)

3.2.1 Space usage in kebele houses

In most kebele houses, the rooms have multi-purposes. The household size is often larger than the number of available rooms therefore the inhabitants adapted to the increase in family size by making their spaces serve multi-purpose. Therefore, a single room can be used as a living room, a dining room, a bedroom, and as a space to prepare food. In some cases, a curtain is used to distinguish between the sleeping space and living space or between the food preparation space and the sleeping space. The use of space is determined by the priority of the household and limited by the availability of space.

Example: 1



This room is inhabited by a family of 4. The living area has a couple of chairs and a bed that is also used as a sitting space. This space is used to entertain guests and also used as a dining area during the day and as a sleeping space during the night. The room also has a bunk bed separated by a curtain where the children sleep. This space also has the injera oven where injera is baked.

Figure 10: Multi-purpose room inhabited by a family size of 4. From: Adapted from a sketch in 'Kebele' Houses: Past, Present and the Future (2014), by Author, 2021

Example: 2

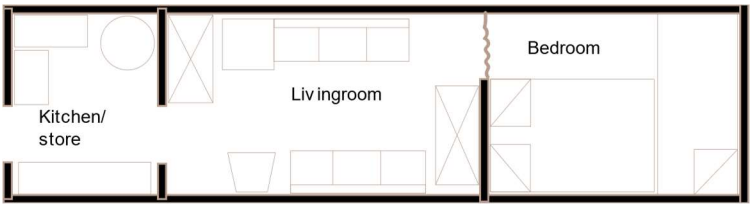


Figure 11: Kebele house inhabited by a family size of 7. From: Adapted from a sketch in 'Kebele' Houses: Past, Present and the Future (2014), by Author, 2021

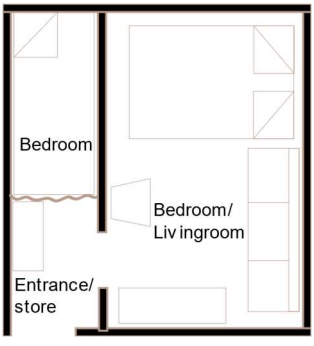
The house is habited by 7 people and it has three rooms, the first room is used as a cooking and storage space. The second room is used as a living space and dining space, the sofa alternatively serves as a sleeping space at night. The third room has a queen-sized bed and a bunk bed where the parents and children sleep. The family also shares a kitchen and a bathroom (not depicted in the image) with 10 households.

Example: 3

This house is inhabited by two families that inherited the kebele house from their parents. The house is partly commercial, a part of the residential space was converted to commercial after approval from the woreda administration. The commercial section is rented at a much higher cost. The largest room is used as a living room and ed room by the first family, the second-largest room is used as a bedroom space for the second family. The third-largest room is a shared space used for cooking and storage space. The smallest room is a street-facing commercial area used by the first family. The two families living in one household share a bathroom with 5 other households.

Figure 12: A house inhabited by two families. From: Adapted from a sketch in 'Kebele' Houses: Past, Present and the Future (2014), by Author, 2021

Example: 4



This house is inhabited by two siblings that inherited the house from their parents. Originally the house used to be one room; the bedroom and living room which is inhabited by one of the siblings and her family. An extension room was built in what used to be the verandah to make a sleeping space for the other sibling, the space is also partitioned by a curtain and used as a storage and cooking space. They share a bathroom with 3 other households.

Figure 13: Two room kebele house. From: Adapted from a sketch in 'Kebele' Houses: Past, Present and the Future (2014), by Author, 2021

Tenants of kebele houses are socially co-dependent on each other and they have a strong sense of community. The available space in comparison to the number of people per household is small, but the households have adapted by making the rooms serve multi-purpose. As shown in the examples a room can

be used for several activities commonly used for living, dining, cooking, and sleeping. It is also seen that space sharing for the kitchen and bathroom is quite common. Outdoor spaces are used as extensions for carrying out domestic activities such as cooking, washing clothes, and other social and communal activities.

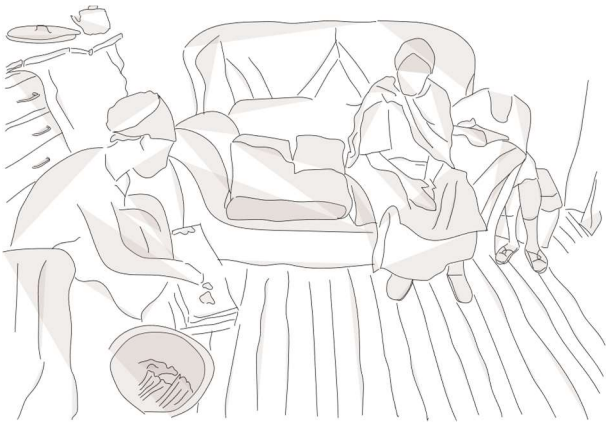


Figure 14:Living space also used to prepare food. From: Digital sketch produced from picture taken by Anteneh Tola (ongoing PhD), 2020

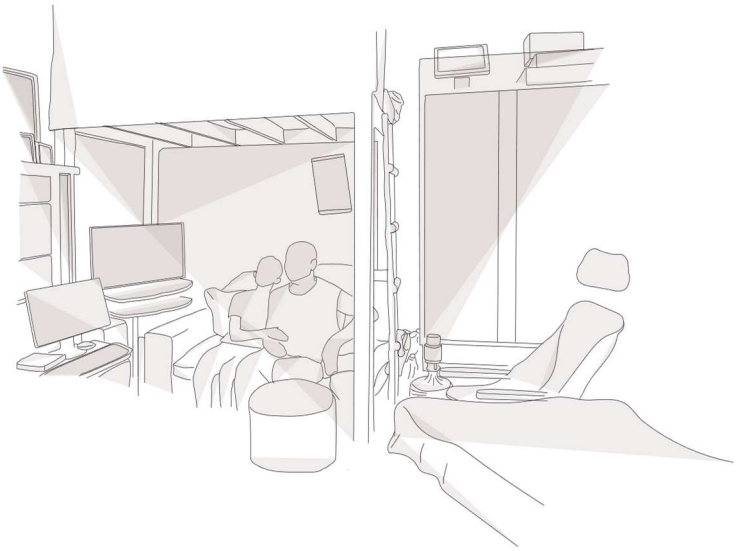


Figure 15: A bunk bed placed over the sofa in the living room. From: Digital sketch produced from picture taken by Anteneh Tola (ongoing PhD), 2020

Figure 16:preparing coffee in the living room. From: Digital sketch produced from picture taken by Anteneh Tola (ongoing PhD), 2020

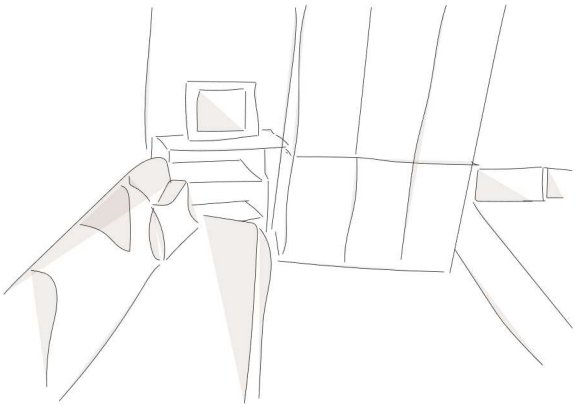


Figure 17: Living space and sleeping space in one room. From: Digital sketch by author,2020

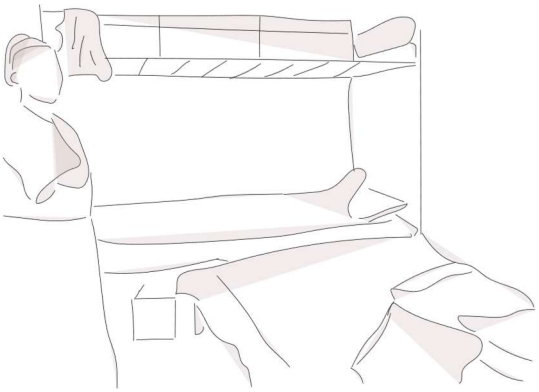


Figure 19: Bunk beds in sleeping space.

From: Digital sketch by author,2020

Figure 20: Kitchen and storage space. From: Digital sketch by author.

Figure 18: Elders Enjoying Coffee From: Digital sketch produced from picture taken by Anteneh Tola (ongoing PhD), 2020

Figure 21: Preparing coffee in living space. From: Digital sketch produced from picture taken by Anteneh Tola (ongoing PhD), 2020

Figure 23: Living and sleeping space separated by curtain. From: Digital sketch produced from picture taken by Anteneh Tola (ongoing PhD), 2020

Figure 22:Ladder leading to added attic space. From: Digital sketch produced from picture taken by Anteneh Tola (ongoing PhD), 2020

A

B

Figure 24: A- Washing in the courtyard space curtain. B. Indoor cooking space partitioned by a curtain. From: Research booklet a companion to Mengeste, 2020.

Figure 25: Drying and preparing spices in courtyard space. From: Digital sketch produced from a picture taken by Anteneh Tola (ongoing Ph.D.), 2020

Figure 27: drying washed clothes over the courtyard space on ropes spanning from house to house. From: Digital sketch produced from picture taken by Anteneh Tola (ongoing PhD), 2020

Figure 26: Washing clothes on courtyard space. From: Digital sketch produced from picture taken by Anteneh Tola (ongoing PhD), 2020

Figure 28: Young girls having a conversation in the courtyard space while washing clothes. From: Digital sketch produced from a picture taken by Anteneh Tola (ongoing Ph.D.), 2020

Figure 29: Entrance to two households. From: Digital sketch produced from a picture taken by Anteneh Tola (ongoing Ph.D.), 2020

Figure 30: Courtyard as a play area for kids. From: The picture was taken by Anteneh Tola (ongoing Ph.D.), 2020

3.2.2 Home-based income generation in Kebele dwellings

Home-based income generation in low-income dwellings takes place in 3 spaces. These are within the built dwelling unit, in courtyards and streets adjacent or on nearby streets.

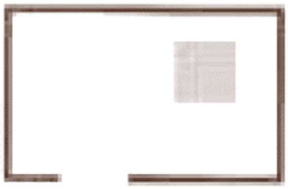
a. Small scale production – within the dwelling unit

A

B

Figure 32: A- Tailoring B- Baking Injera.
Source: Alemena (2015), exploring the use of domestic spaces for home based income generation

A



B

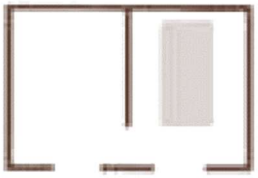


Figure 31: A- Within the dwelling unit. B- In shared spaces. From: Exploring the use of domestic spaces for home-based income generation, by Alemena , (2015)

b. Production within the shared compound

Income-generating activities that take up more space are first conducted in the compound, if the compound doesn't accommodate the production activity, the activity moves to the immediate street.

Figure 34: Production within the shared courtyard. From: Ongoing Ph.D. research by Anteneh Tola, (referred 2021)

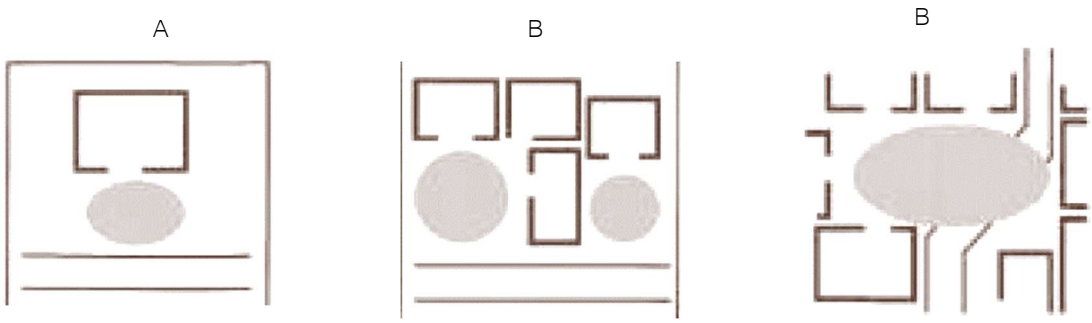


Figure 33: A- exlusive courtyard, B- shared courtyard, C- Courtyard with streed. From: Exploring the use of domestic spaces for home-based income generation, by Alemena , (2015)

c. Street adjacent production and sales

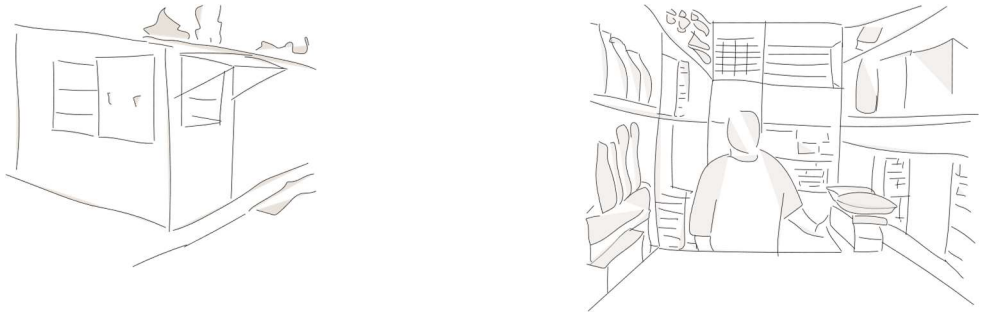


Figure 35: Street adjacent shop. by: Digital sketch by author,2020

Figure 36: Production and sales on street level.
From: Exploring the use of domestic spaces for home-based income generation, by Alemena , (2015)

The table below shows where different activities take place in different spaces.

Activity				
Domestic		Income generating		
Indoor	Outdoor	Indoor	Outdoor	Street Adjacent
Bedroom	Preparing spices	workshop	drying	shop
Living room	Drying	kitchen	Preparing	
Dining Room	Washing			
Bathroom	Communal gatherings			
Kitchen	Entrance			

Table 2: Activity summary: by Author

Interchangeable space	Shared space
Bedroom	Bathroom
Living room	Kitchen
Dining Room	Courtyard
	Main Entrance

Table 3: Space sharing. by Author

3.2.3 Incremental growth in Kebele houses

Incremental growth of kebele houses happens for various reasons among those the most common ones are the growth in family size, the addition of a commercial unit, change in spatial needs, and improvement in the financial situation of a household.

Figure 37: horizontal expansion structures.From: Ongoing Ph.D. research by Anteneh Tola, (referred 2021)

Households add rooms incrementally either horizontally or vertically. The addition of rooms horizontally occurs when there is available uncontended space. Where horizontal expansion is not possible, attic spaces are added vertically and that is usually accessed through ladders/stairs.

Figure 38: Added attic space. by: Author

3.3 HOUSING POLICY

3.3.1 Housing development principles, goals, and strategies

According to the Addis Ababa Structure plan (2017-2027), a total number of 1,172,195 housing units need to be built during a period of (2017-27)in Addis Ababa. The guiding development principles in meeting the housing demand are "affordability, social mix, compact development, and strong government intervention in the delivery, improvement of quality of housing stock and living environment through upgrading and renewal, and linking employment creation efforts with housing programs"(*Addis Ababa City Structure Plan DRAFT FINAL SUMMARY REPORT*, 2017).

As part of the goal of improving the quality of the housing, and the living situation in slum neighborhoods, several strategies have been proposed in the Addis Ababa structural plan (2017-2027). These include:

Income group	Share by 2002 (%)	Share by 2012 (%)	Share by 2023 (%)	Share of housing units by 2023
Low income	80	66	35	**420,000**
Middle income	16	26	50	**600,000**
High income	4	8	15	**180,000**
Total	100	100	100	**1,200,000**

Table 4: Projected Housing Demand per income group.
From: Addis Ababa Structural Plan (2017-2027)

In-situ redevelopment: Improvement in the living environments of residents without relocation keeping the socio-cultural and economic networks intact.

Conditional privatization of government-owned houses: "Privatization" of kebele houses to sitting tenants upon fulfillment of minimum level of improvement standard.

Plot rearrangement and compulsory public space sharing: Introducing a neighborhood level plot re-arrangement and partnership agreements to introduce infrastructure and communal facilities.

An independent design jury: The structural plan proposes an independent jury comprised of professionals in the architecture and urban planning industry along with higher educational institutions, the city's government bodies and the residents be established to judge submitted designs and quality of build. This is a post evaluation of design proposals without prior engagement of the stakeholders in the design process.

3.3.2 Proposed Housing typologies

The housing typologies for low-income groups as proposed in the Addis Ababa Structural plan 2017-27 are of two main types. The first type is High rise buildings (G+4 & G+5) with variants of skeleton/semi-finished units, subsidized finished units, and subsidized townhouses (G+2). The second type is referred to as special housing type (50m2/household) with variants of incremental housing (up to G+2 & G+1).

Income groups	Housing types	Total number of houses for each group
Low income	High rise • Skeleton/ super structures or semi-finished units in walk-up buildings (G+4 and G+5) • Subsidized finished units in walk-up condominium buildings (G+4 and G+5) • Subsidized town houses (the so called studio types in G+2 stories Special housing • Incremental housing in site and service schemes (50m2/household) up to G+2 stories • Chika houses in site and service schemes (50m2/household) with possibility to accommodate vertical development (G+1)	35% 420,000
Middle income	• Walk-up condominiums (20/80 types) • Incremental housing on single plots (73 and 94m2) • High rise buildings (40/60)	50% 600,000
High income	High rise • Walk-up apartments (G+4 and G+5) • Luxury apartment houses (40/60 condominium buildings and others) Special housing • Special houses in the form of villas and multi-storey individual buildings on single plots	15% 180,000

Table 5: Proposed housing typology.From: Addis Ababa Structural Plan (2017-2027)

3.4 URBAN UPGRADING AND AFFORDABLE HOUSING PROGRAMS

3.4.1 Sites and services

The government allocated a 160m2 plot to dwellers for the sites and services program in Nifas silk, Addis Ababa. The project was approved in 1983 and completed in 1991. Construction loans were given to participants with preference given to those organized in cooperatives. This allowed for community participation in the design decision-making and project management process. The housing cooperatives constructed the low-income dwellings through a self-help process. There was three variant of houses, type A was a 11m2 room with detached kitchen and toilet constructed with hollow concrete blocks. Type B was 2 rooms each 11m2 constructed with wattle and daub with detached units of kitchen and toilet. The third type, type C was the same as type B but constructed using HCB. Throughout the years since completion, the dwellers built incrementally both horizontally and vertically showing different variations.

3.4.2 Mass Housing

To address the ever-increasing housing demand and better the poor living environment of low-income communities in Addis Ababa, the city government introduced several interventions. One of the interventions carried out at a large scale was the Addis Ababa Grand Housing Program. The project was conducted with German technical cooperation with the first pilot project completed in 2004. The constructed buildings are 4-5 stories high containing studio, one Bedroom, two Bedroom, and three Bedroom apartments. The Integrated Housing Development Program (IHDP) was introduced in 2005. The program aimed to reduce informal dwellings by 50% The government builds multi-story condominium apartments and transfers ownership to the public based on a lottery selection and matching system from a list of recorded non-homeowners

within the city. There are three housing schemes, 10/90, 20/80, and 40/60 based on the percentage of down-payment required. Winners selected by the lottery system have to pay a down payment of 10-40 % depending on the selected housing scheme, where the remaining payment is covered by the government as a long-standing loan. The condominium projects are constructed on vacant land, on expansion areas of the city, and on land acquired by clearing inner-city slum neighborhoods. In most cases or inner-city slum renewals, the residents evicted from the renewal site were relocated elsewhere.

3.5 AFFORDABLE HOUSING TYPES AND COST

Income group	Share of the total by 2023 (%)	Number of houses needed for each group	Housing type and average area coverage	Unit cost (Birr)	Total cost (Birr)	Annual requirement (Birr)
Low income	35%	**420,000**	Studio and 1BR type **30-55 m2**	**38,000-128,590**	210,000 x 38,000= **33,849,774,420** + 210,000 x 128,590= **7,980,000,000** **Total=41,829,774,420**	**4,182,977,442**
Middle income	50	**600,000**	2BR **75 m2**	**200,475**	120,285,000,000	12,028,500,000
High income	15	**180,000**	3BR **100m2**	**320,000**	57,600,000,000	5,760,000,000
Sub Total	100	**1,200,000**			219,714,774,420	21,971,477,442
• Cost of infrastructure= Birr 595/m2 • Total area of the houses x 595 Birr/m2 • (**420,000 x** 43m2average) + (**600,000 x** 75) + (**180,000 x** 100) = **18,060,000+ 45,000,000+ 18,000,000= 81,060,000m2** • **Total cost = 81,060,000m2 x 595 = 48,230,700,000**					**48,230,700,000**	**4,823,070,000**
Total finance needed for the planning period					267,945,474,420	26,794,547,442

Table 6: Cost per proposed typology.
From: Addis Ababa Structural Plan (2017-2027)

3.6 URBAN UPGRADING ACTORS AND STAKEHOLDERS

Urban upgrading activities within Addis Ababa have been carried out by the government and civic societies. Key players in the development of the integrated housing development project were the ministry of works and urban development (MWUD), The Addis Ababa City Administration, the Housing Development Project Offices, the commercial bank of Ethiopia, and NGOs. The MWUD provides a national-level direction, where the city administration manages the program. The HDPOs are responsible for the delivery of design, construction, and transfer. The Commercial bank of Ethiopia is involved in financing the program.

The government bodies responsible for infrastructure upgrading within the city are Environmental Development Office (EDO) and the Addis Ababa city Administration at the city, sub-city, and kebele levels(Elias Yitbarek, 2008). The implementing body of the EDO's are the Kebele Development committees (KDC), the ten-member committees are elected by the dwellers and include representatives from the youth, women, the

elderly, iddir associations, and low-income dwellers. The KDC works closely with the Neighborhood Development committees which are more on a grass-root level.

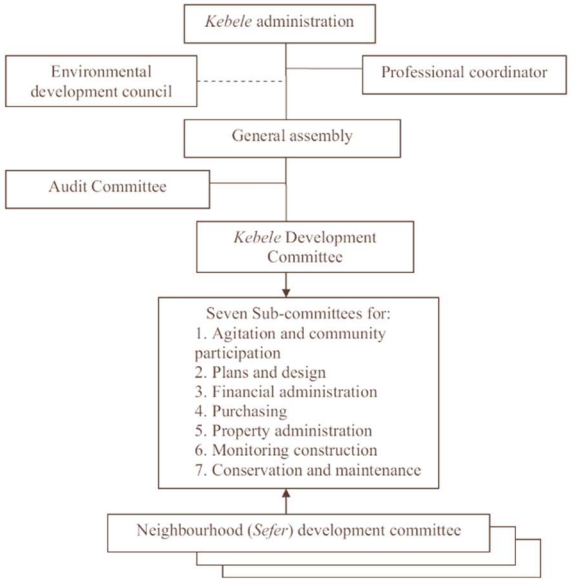


Figure 39: EDO's structure at kebele level.
Source: Adapted from EDO, (2003)

Eco-city urban rehabilitation program is another government initiative created to initiate public-private partnerships with environmental, social, and economic objectives. Eco-city carried out social service, waste management, and sanitation upgrading projects. Eco-city includes a study team comprised of sociologists, town planners, and economists that work collaboratively with the kebele administration and kebele dwellers.

Another actor in urban upgrading is NGOs, usually engaging in health, education, and physical upgrading projects. The NGOs secure funds from international funders and determine a target group. Other actors in upgrading initiatives are community iddirs, iddirs are associations formed by a community to provide each other financial, material, and emotional support for burials.

3.7 SOCIAL STRUCTURES WITHIN THE COMMUNITY

Low-income communities rely on social networks and mutual cooperation. Kebele house inhabitants have a higher degree of socio-economic interdependence and often utilize shared spaces at household, compound, and neighborhood level. There are several social associations formed within the neighborhood community. The most prominent social associations are the iddir, equb, and maheber. Iddir is a neighborhood association that gives financial and material assistance to its members for burial. The iddir is funded by the monthly contribution of the members. Iddirs usually have a storage and meeting space. Iqub is a traditional saving method where money is collected and a lottery is drawn periodically to allocate the collected money to the winner on a rotating basis. This allows the participants access to large sums of money at once that can be used to finance their needs. A mahber is an association established to advance common interests.

3.8 CHALLENGES AND DRAWBACKS OF SLUM UPGRADING AND RENEWAL PROGRAMS

The majority of characteristically slum areas and most specifically kebele houses are located in the inner-city. These kebele houses house low-income communities that rely on the locational advantage to find means of either formal or informal income-generating opportunities. Therefore, upgrading or renewal programs involving relocation threaten the capacity of these low-income communities to generate income. Furthermore, a significant number of low-income inhabitants multitask various activities including home-based production and small-scale trade in addition to carrying out domestic responsibilities; therefore, the segregation of spaces of these simultaneously occurring functions disrupts the daily activities. Relocation also disturbs and often dissolves different existing socio-economic associations formed by the community such as iddir, iqub, maheber,

which are formed to provide financial, material, and emotional support within the participating community. Although Legal kebele house tenants are given the right to condominium housing through the lottery system, low-income households often can't afford the down-payment. In addition to this, the units targeted for low-income households are mostly studio units that cannot accommodate the family size of the low-income households that have 6-10 members(Ashna Mathema, 2005). Elias Yitbarek, Immam Mahamous, and Yonas Alemayehu (2018) argue the provision of humanitarian shelter for low-income inhabitants with reduced large-scale destruction of functioning communities with a socio-economic mix can only be achieved through meaningful participation of the low-income residents themselves.

3.9 INCREMENTAL HOUSING AS A SLUM UPGRADING STRATEGY

3.9.1 Case study

A. Incremental housing strategy: Rehabilitation Scheme for Urban Poor Staying in Slums in City of Pune

a. About

The project is located in Yerawada, a slum in Bombay to develop housing solutions for 4000 families(" Belapur Incremental Housing - A Case Study," n.d.). The project is aimed at developing an approach to transform slums into lasting urban regions through a course of gradual improvements of present dwellings.

The project uses current urban formation as a base for starting development, with the guiding principles being to preserve existing social networks. Individual houses are demolished and rebuilt where the family can customize their own house and build in an incremental manner("Archdaily: Incremental Housing Strategy in India," n.d.).

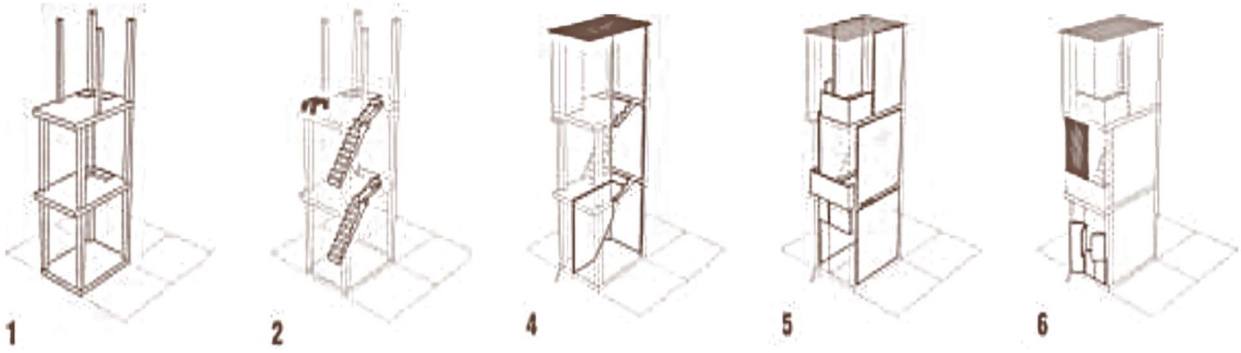


Figure 40: Incremental house formation. Source: Incremental housing India p.9

b. Participation:

Figure 41: Community Participation. From (https://www.archdaily.com/21465/incremental-housing-strategy-in-india-filipe-balestra-sara-goransson)

Participants in the design are Architects, Urban planners, SPARC, NGOs, and end-users. The design allows families to customize their own house and increment as the family size/income grows.

c. Typology:

Three house typologies were developed:

House A: A housing typology developed as a two story building with the structural capacity to be incrementally developed to a three story building.

Figure 42: Typology A. From (https://www.archdaily.com/21465/incremental-housing-strategy-in-india-filipe-balestra-sara-goransson)

House B: A housing typology with three stories where the ground floor can be used as a parking space or can be turned into a commercial space/ shop.

Figure 43: Typology B. From: (https://www.archdaily.com/21465/incremental-housing-strategy-in-india-filipe-balestra-sara-goransson)

House C: A housing typology with three stories where the middle story is left open to be used as a veranda , which can be closed off to create internal habitable spaces if needed.

Figure 44: Typology C. From: (https://www.archdaily.com/21465/incremental-housing-strategy-in-india-filipe-balestra-sara-goransson)

d. Clustering:

The first type of clustering is where the adjacent houses share a structure but each house will have private access, stair, and verandah.

Figure 45: Cluster type 1. From: Incremental housing India

The second type of clustering is where different households use common stairs and share small public squares.

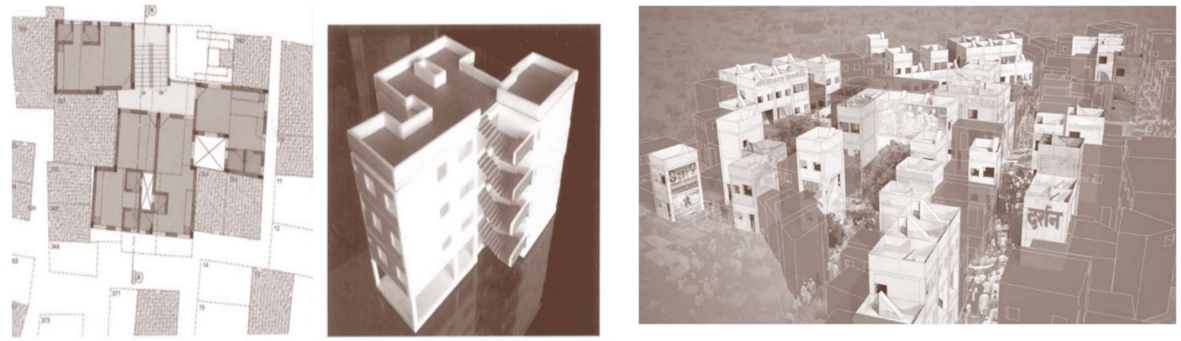


Figure 46: Cluster type 2. From: Incremental housing India

B. Aranya Housing Project

About:

Aranya Low-Cost Housing is initiated by the Indore Development Authority, the housing clusters are formed by houses joined by courtyards and internal pathways. The site is divided into six areas that collectively house 6,500 residents. The project accommodates different income groups and provides housing options of varying sizes ranging from 35-475m2 ("Aranya Community Housing," n.d.).

The slum redevelopment project took inspiration from the exiting slum settlement to incorporate spaces tht extend to the outdoors connecting neighbors and forming small neighborhoods. The public spaces had trees and the streets were designed to allow various activities to take place, these forms the socio-economic bond between residents. The housing units are arranged in a way that the long façade is in the north-south direction to reduce solar heat gain. The smaller plots are clustered in low rise building types ("All You Need To Know About Aranya Community Housing," n.d.).

The project stated with the aim to cater to low-to middle income residents in an integrated community. The location of the project, being close to the city center, also gives locational advantage to the low-income residents.

Participation:

The project followed a sites-and-services planning where basic infrastructure is provided for the residents to build their individual dwellings incrementally overtime. The basic infrastructure includes plumbing services, water and electric supply as well as road networks. The residents can build incrementally as per their needs and economic capacity ("Balkrishna Doshi's Aranya," n.d.).

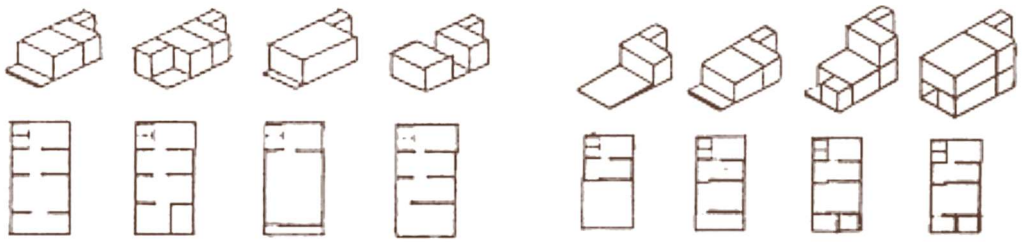


Figure 47: Incremental growth. From (https://www.architectural-review.com/buildings/revisit-aranya-low-cost-housing-indore-balkrishna-doshi)

The dwellers can arrange their space according to their needs, and increment by adding floors, and rooms according to the needs of the dwellers and the activities to be accommodated.

Typology:

The types of houses differ by the number of floors, types of stairs and openings used. The EWS residential cluster typically is configured with a verandah, 2 rooms, a kitchen, a service core toilet, and a bathroom.

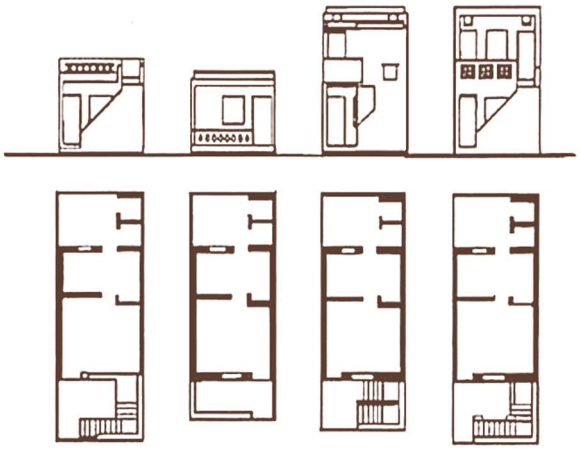


Figure 48: Form and plan variations. From (https://www.slideshare.net/kushaAhmed/aranya-low-cost-housingbv-doshi)

The architect designed various types of buildings using the same principles to display the possibility of customization by user. Different typologies are possible, small as a single room to larger spacious houses.

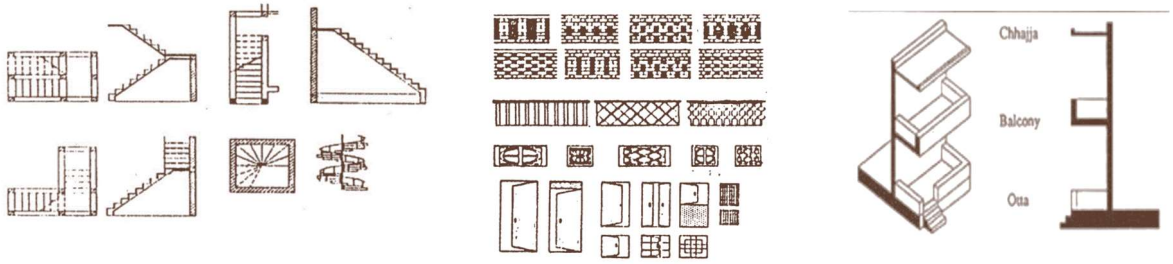


Figure 49: Kit of parts. From (https://www.architectural-review.com/buildings/revisit-aranya-low-cost-housing-indore-balkrishna-doshi)

Clustering:

At the tissue level, the design has inter-connected open spaces, built-up spaces, spread-out amenities, and a hierarchical road network. The site is divided into 6 sectors, each one has a residential cluster, community spaces, road networks, and green spaces. The residential clusters are mainly 4 types. These are EWS, LIG, MIG, and HIG.

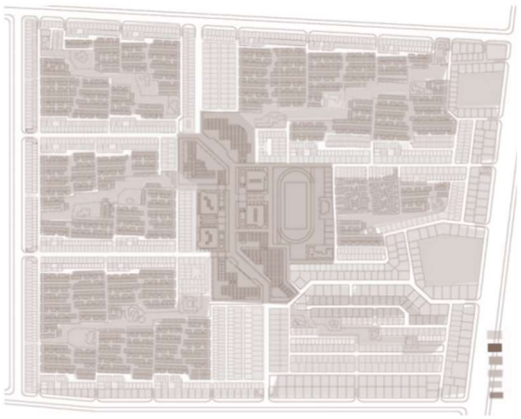


Figure 50: Master plan. From (https://www.slideshare.net/kushaAhmed/aranya-low-cost-housingbv-doshi)

The housing blocks forming the cluster have spaces reserved for commercial and communal activities.

A cluster is formed by ten houses that each have a courtyard at the back connected to the street.

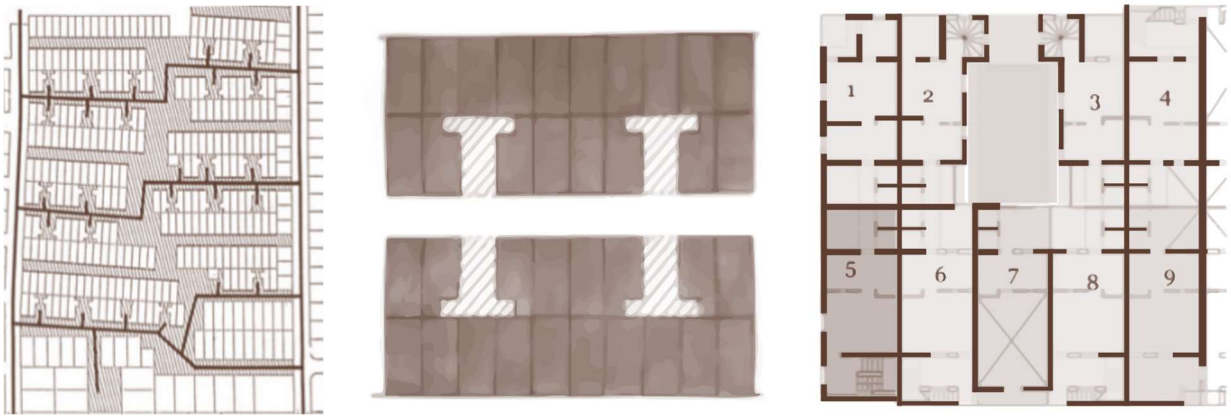


Figure 51: Clustering From: (https://www.slideshare.net/kushaAhmed/aranya-low-cost-housingbv-doshi)

C. Belapur Housing

About:

The Belapur housing is an incremental housing project designed by Charles Correa in 1983-86 on 6 hectares to accommodate Bombay's low-income groups. The project is located 1km away from the city center of New Bombay. The housing projects demonstrate high densities with 500 persons per hectare with a variation of 45m2-70m2 of low-rise house typologies(Mendes et al., 2013).

The project allocates individual plots for each dwelling unit that allows the dweller to incrementally develop as needed. The dwelling units do not have a common wall allowing them to expand without interference

within the boundary of their plot. The project is characterized by open spaces, incremental development, equity and communal spaces (Priyanka Chapekar, n.d.).

Participation:

Charles Correa argues that the involvement of the residents plays a crucial part in housing projects("Belapur Incremental Housing - A Case Study," n.d.).
"*Making housing is like a bird building a nest. You start with a basic house, but you have to let people change it on their own needs*."

Typology:

There are five different types of typologies depending on the ethe size of the plot and built-up space. The smallest typology has one room and a toilet. The largest module is a two-story building. In all the typologies, the neighboring houses in a cluster do not share a wall apart from those requiring plumbing services (Priyanka Chapekar, n.d.).

The housing units are clustered in way that it only has one side with a shared boundary. Windows cannot be placed on the shared boundary. The building is constructed using a load bearing masonry that can easily be constructed locally by unskilled labor (Priyanka Chapekar, n.d.).

The typology forms are different varying from 45 meter square to 70 meter square.

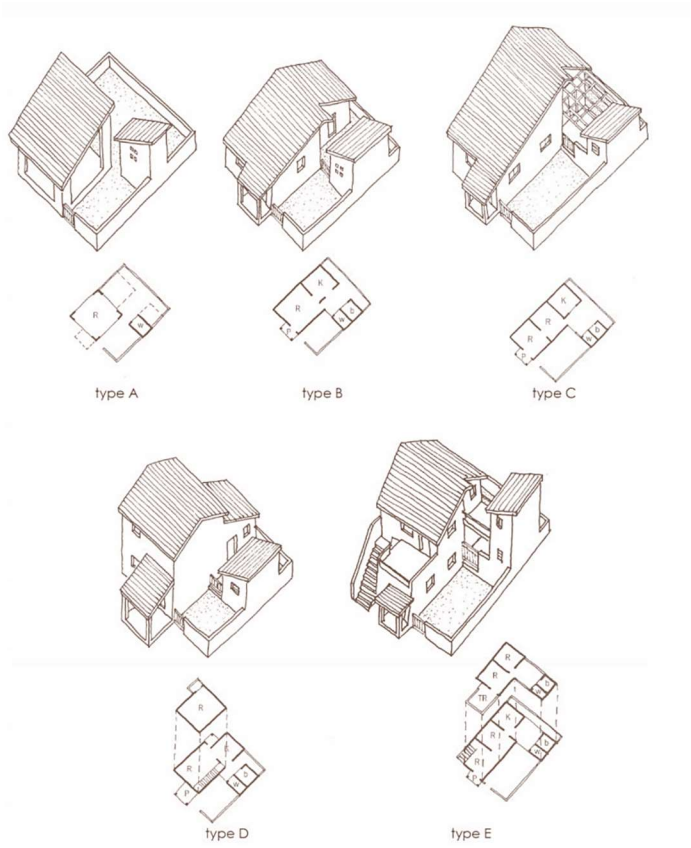


Figure 52: Typhlology of Belapur housing. From: "architectopedia" (https://architectopedia.com/belapur-housing-by-charles-correa-case-study/)

Type A is the smallest unit, consists of a single room a toilet, and a yard. Type B consists of one room, a kitchen, a bath, a toilet, and a yard. Type C has two rooms plus a kitchen, a bath, a toilet, and a yard. Type D is a two-story building with two rooms, a kitchen, a bath, a toilet, and a yard on the ground floor along with a studio and balcony on the first floor. Type E is a two-story building with two rooms, a kitchen, a bath, a toilet, and a yard on the ground floor accompanied by two rooms, a bath, a toilet, and a terrace on the first floor.

Clustering:

The clustering of the houses is based on a hierarchy of open spaces. The smallest level of clustering happens at an individual household level using the individual yard of each house. The dwellings are designed to be freestanding allowing them to increment according to their needs by a means of self-construction.

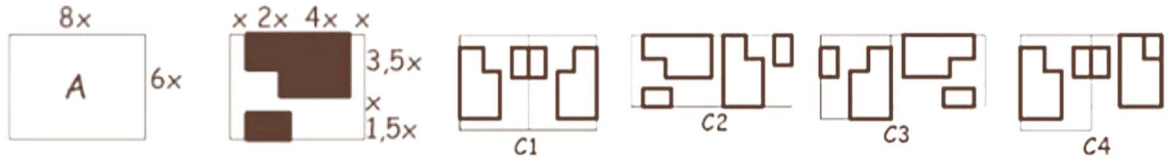


Figure 53: Belapur Cluster From "Belapur incremental housing – A case study" (https://www.slideshare.net/rithikarockingravishankar/belapur-incremental-housing-a-case-study)

The next level of clustering is the cluster of 7 households around an 8m * 8m courtyard forming the first level of communal cluster. Every cluster includes a variety of housing typologies and a central open space. Three of the first level cluster are arranged around a 12m*12m courtyard forming the second level cluster. The third level of cluster is formed by three of these second-level clusters arranged around a courtyard space of 21m*21m.

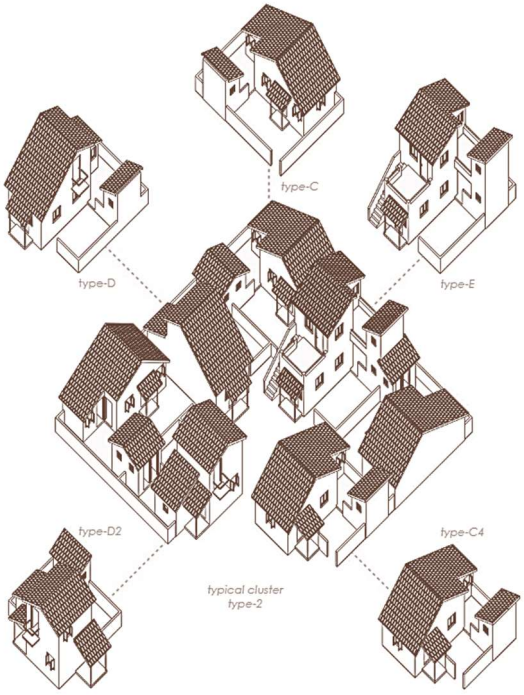


Figure 54: First-level cluster. From: (https://issuu.com/gunjanmodi/docs/gunjan_modi_thesis_page)

Figure 55: Levels of Cluster From: (https://www.slideshare.net/rithikarockingravishankar/belapur-incremental-housing-a-case-study)

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Elias Yitbarek. (2008). *Revisiting «Slums», Revealing Responses : Urban upgrading in tenant-dominated inner-city settlements, in Addis Ababa, Ethiopia*.

Mendes, L., Beirao, J., Duarte, J., & Celani, G. (2013). *A bottom-up social housing system described with shape grammars*.

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CHAPTER IV

4 CHAPTER 4 - DESIGN DEVELOPMENT

4.1 DESIGN BRIEF

The design brief is to create a tangible and visual method for eliciting the shareholder's spatial needs using a game-based approach. The design game resembles a board game in conjunction with Lego and functions on a more abstract level in relation to the built environment. The design game is intended for use in a collaborative design that allows end users to configure their space based on their spatial requirements and priorities which otherwise may not be met by standard conventional design in the top-down approach. The design game will essentially abstract and simplify low-rise courtyard-based incremental housing design into a system of simple configurational rules and design elements that allows the stakeholders to easily engage in the design process. This system of design flows a modular co-ordination system based upon a tartan grid. The end users use the game elements (boards, modules, activity cards & tokens) to configure their space based on the defined game rules. In the game play process, the stakeholders (players) will identify and weigh different domestic and commercial spaces, functions and sizes based upon their priority to form their configuration of hierarchic spatial framework and shared spaces. The game will serve as a simulation of a design problem that facilitates trade-offs, design ideation, projection of stakeholder needs and preferences, and co-creation.

4.2 PLANNING THE DESIGN GAME

The design game is planned in 3 stages. As mentioned earlier, the design game is used for generating collective design for low-rise courtyard based communal housings. The first stage of the game is to layout the clustering of the houses in a way that the courtyard is central. This stage of the game is the cluster level. To do this, boards representing plots are designed, these boards can be connected in a number of ways continuously to form a chain like cluster with a central courtyard. The second level of the game is the configuration level. Here the players (stakeholders) can configure their houses and shared spaces using a set of predefined modules according to their needs and preference. The players use their tokens to acquire modules. To compensate for the limited space (module acquired), the player can choose to use the shared courtyard space as an extension to their home activities by indicating it using the activity cards. The third level of the game is formation level. Following the chosen building system and material, the players can select the wall, opening and roof type of their configured space. Here, other modifications may take place, such as determining wall thickness based on structural requirements, and functional use (load bearing or partition walls).

4.3 GAME COMPONENTS

Grid: is the modular coordination system for the game pieces.
Board: - is the space budget for each player.
Modules: are volumetric representation of functional spaces, every module has a value assigned to it.
Tokens: are used to acquire modules and can be equated to real life value (cost) of building the module.
Activity cards: are activities that players can select to take place in the shared courtyard space.

The game interface is based on a tartan grid system. The grid defines the dimension and positioning of the game pieces. The board represents the plot or space budget allocated for each player. The modules are of different sizes based on the grid and have different functions assigned to them. Each module has a value

assigned to it. The players can use their tokens to acquire a module. The value of shared modules is shared by the players sharing the module. Each player can select activity cards that they wish to carryout in the shared courtyard space.

4.3.1 Definition of the grid

Using a grid system is helpful to express design rules used to formulate a layout. It facilitates design decision making by the use of placement rules of elements in reference to the grid allowing the designer to easily and systematically configure layouts of what could be complex designs. The use of grids can be used to mediate group work, where the placement rules guide designers to place elements while also giving them the flexibility to explore various layout configurations without having to face significant interference problems while integrating their collective design (Mark D. Gross, 1991).

The meta game is based on a modular system where by the defined modules are based on a 3-dimentional grid. The definition of the grid is proposed in such a way that it allows for flexibility in accommodating different sizes of modules and their related function. The grid size is often determined based on the thickness of the building elements and the allocated space. The dimensions of the building elements can vary based on various factors including the type of material and the structural property. To accommodate this variable, a tartan grid with bands for placing loadbearing elements can be used.

To define the grid size, which is referred to as a tile, the minimum spatial dimension required to carry out domestic and home-based income generating activities in low-income housing context was considered in addition to standard residential dimensions. Circulation spaces play a vital role in determining the grid size. The standard of having a minimum of 90cm corridor for residential spaces was considered.

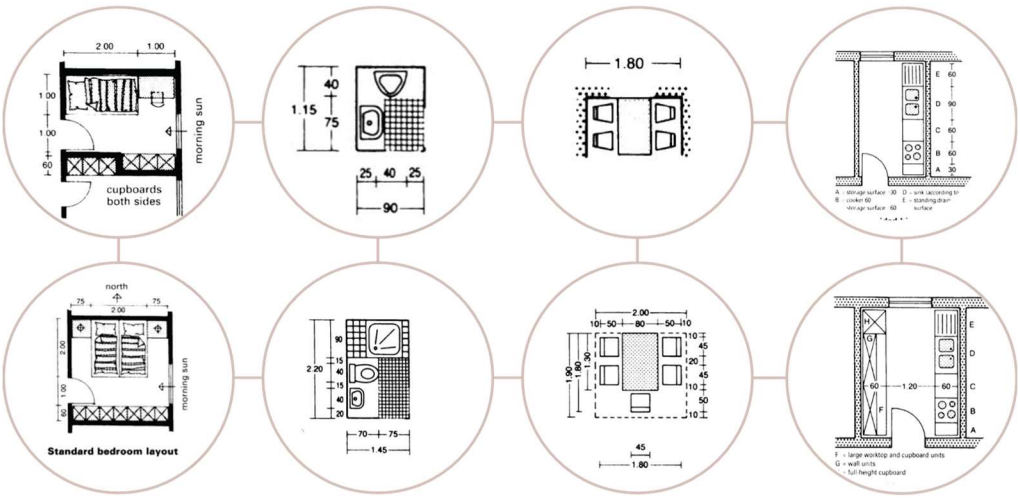


Figure 56: space standard dimensions. Architect's Data, by Ernst and Peter Neufert

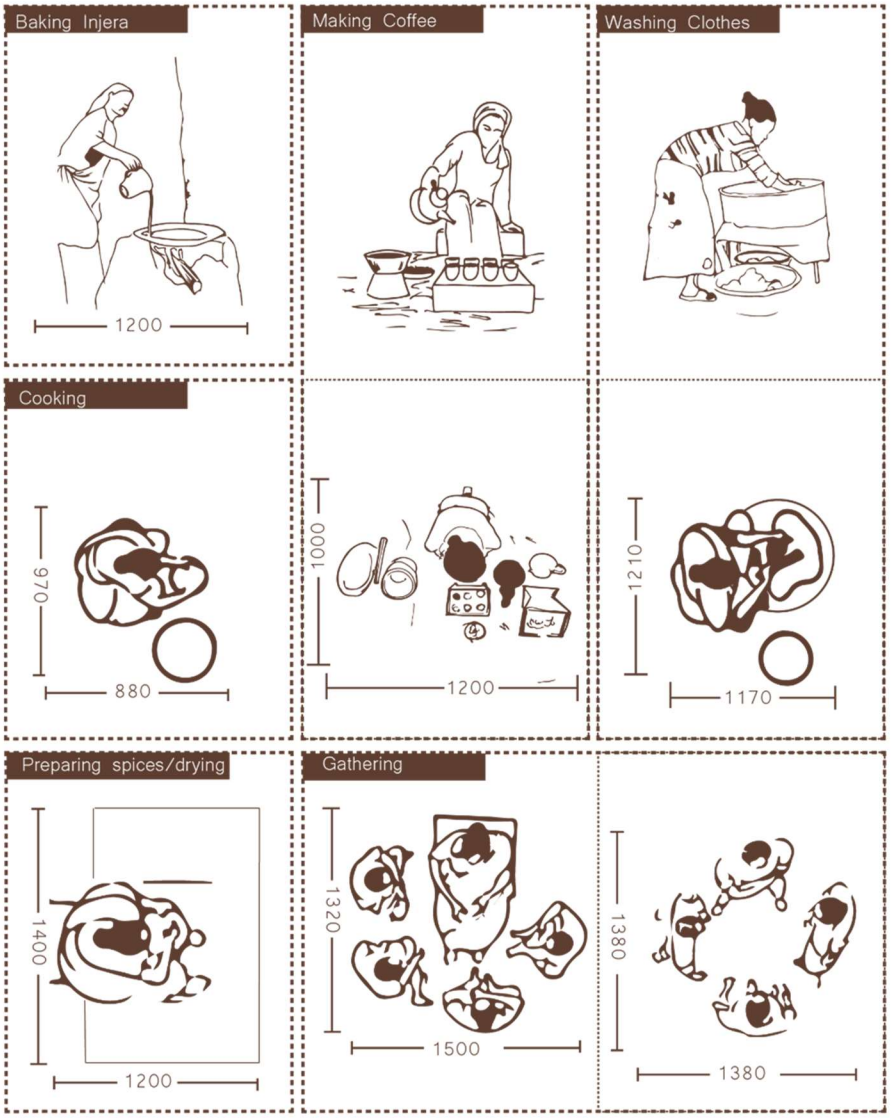


Figure 57: Activities and space. Partly from: How the other half builds

A double band tartan grid is used to give more flexibility for the use different building elements and materials. Based on the dimensional study, an internal space of 1m * 1m is considered to be the smallest spatial dimensional unit. By incorporating an additional 20cm band on all edges for placing building elements, the outer bounds of the grid/tile would be 1.4m*1.4m.

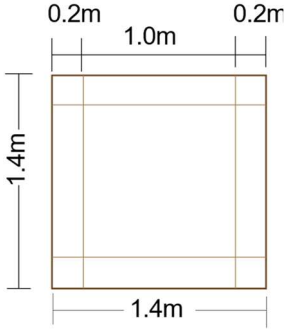


Figure 58: Grid dimension of a tile. by Author, 2021

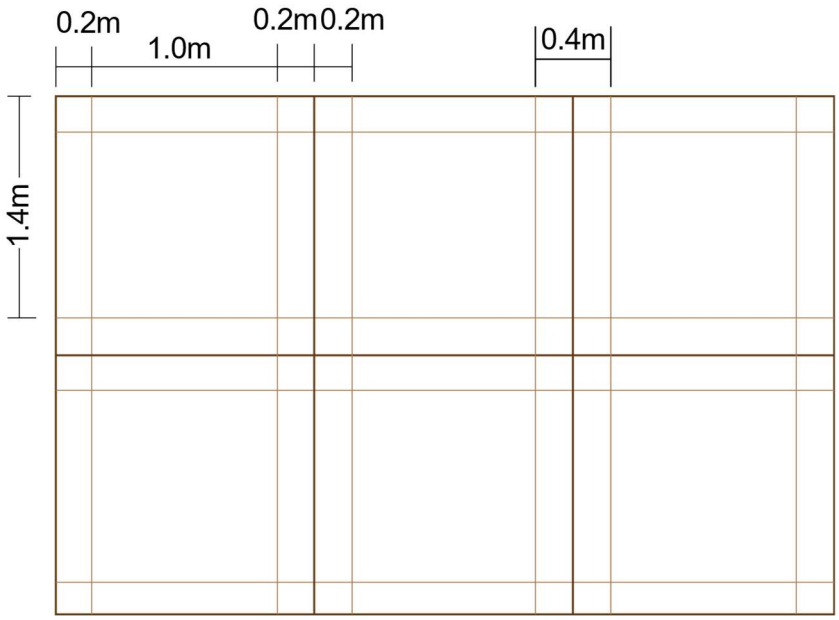


Figure 59: Double band tartan grid. by Author, 2021

The 3-dimentional definition of the grid is also considered using the dimensions of the vertical circulation. The formula developed by the French architect François Blondel (2 risers + 1 Thread = 63-65) was used to ensure the dimension of the stairs is comfortable and efficient for use.

$$2\ \text{risers} + 1\ \text{Thread} = 63\text{-}65 \qquad 2\ (18\text{cm}) + 1\ (28\text{cm}) = 64$$

Equation 1: stair dimention

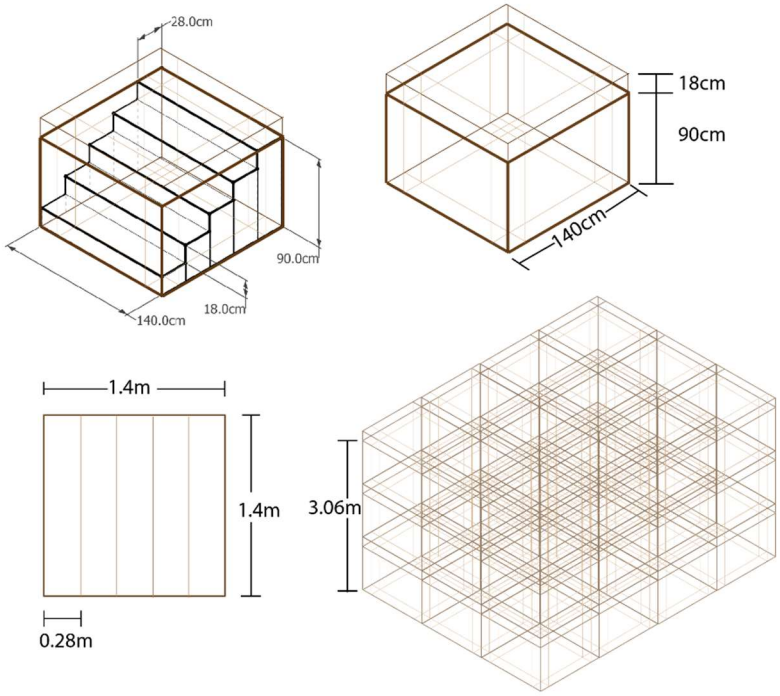


Figure 60: 3-dimentional grid. By Author, 2021

A total of 5 steps with a riser of 18cm fits on one tile (1.4m * 1.4m) reaching a height of 90 cm. A height of 3.06m is achieved by using 17 steps where 15 steps fit into 3 tiles and 2 steps fit into 2 landing tiles. This is further illustrated in the Modules sections.

4.3.2 Definition of space budget and Game board

The proposed space budget is based on the Addis Ababa Structural plan (2017-27) document. Here the government proposes a space budget of 50m2 special housing types for low-income groups.

These are described as:

-Incremental housing types for site and services scheme (50m2/ household) up to G+2 stories.

-Chika house in site and services scheme (50m2/household) with possibility to accommodate vertical development up to G+1 (Addis Ababa City Structure Plan DRAFT FINAL SUMMARY REPORT, 2017).

In the meta game, the space budget is translated into a game board divided into tiles on which players can place modules to configure their spaces. Therefore, each gameboard corresponds to the space budget (in this case 50m2) allocated to each household. The gameboard is designed in a way that it can be configured to form clusters. First the space budget is approximated using tiles (1.4m *1.4m) derived from the grid definition. After which a given number of tiles are dedicated for shared space and for courtyard space. The rest is the buildable space where each household can relatively independently configure their own space.

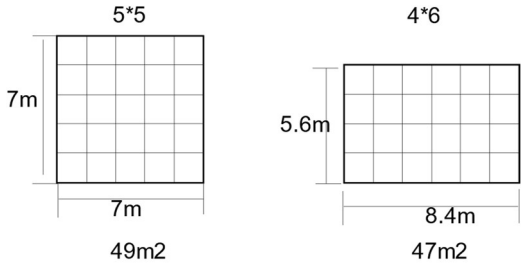


Figure 61: Space budget tiles. by Author , 2021

Three different types of boards are defined; each board is made up of 3 different tiles. A tile is the smallest grid module, it is a square with size 1.4m * 1.4m. The different types of tiles are: a shared space tile, where shared modules can be placed. The buildable tile, where room modules can be placed. And a courtyard tile, which should always face towards the central courtyard.

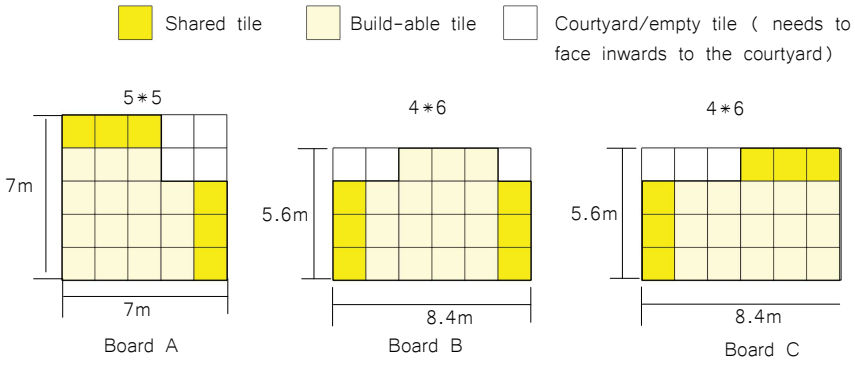


Figure 62: Game boards. by Author

The boards are used to form clusters in a courtyard. Each board corresponds to the space budget for one household. By connecting the shared space tiles of the boards, different clusters can be formed based on the number of households.

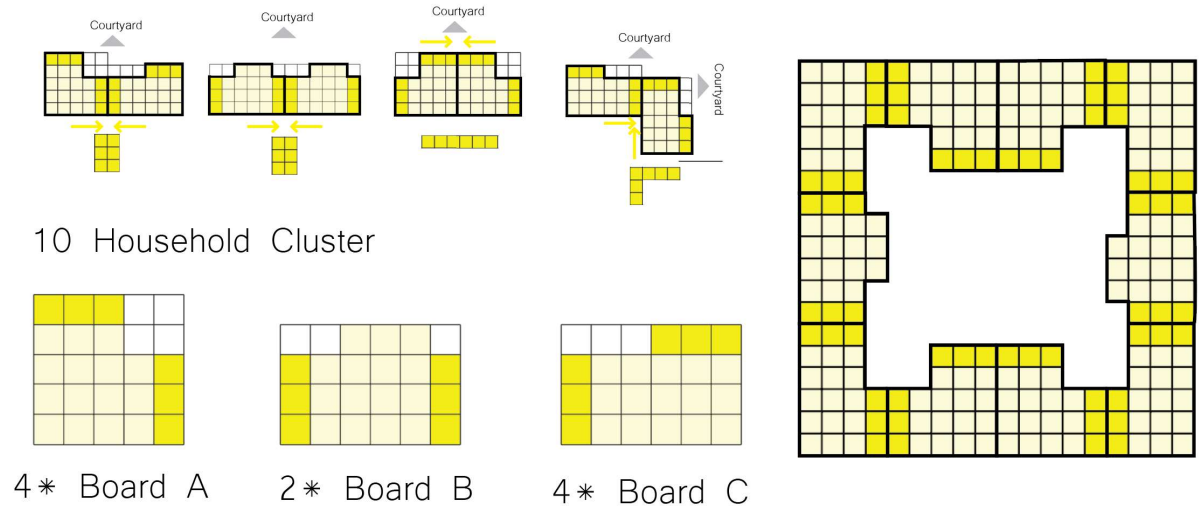
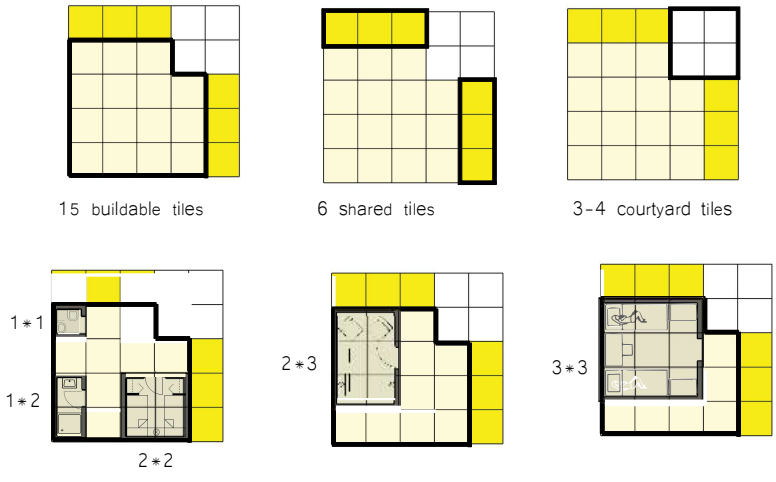


Figure 63: Example of a cluster. By Author, 2021

The players can define their own boards by adhering to the following rules.

1. The board size must be an approximation of the space budget abstracted by the use of tiles (in this case 50 m2 of space budget and 1.4m*1.4m of tile size).
2. A board must include 15 Buildable tiles connected to each other.
3. The buildable tiles must be connected, and can accommodate 1*1, 1*2, 2*2, 2*3 and 3*3 tile room modules.
4. There must be 6 tiles for shared spaces, placed on the edges.
5. There must be 3-4 courtyard tiles.



Different size of modules placed on the buildable tiles.

Figure 64: Example of a bord that meets the rules. by Author, 2021

4.3.3 Definition of Modules

The modules defined in the meta game are abstracted volumetric representation of spaces. This module can be configured in multiple ways generating diverse configurations. The module definition and configurations somewhat draw inspiration from the plastic construction Lego toy that utilizes a range of pieces that can be assembled to produce a multitude of creations.

Based on the studied patterns of habitation, various modular units are defined. The modular units are categorized into circulation modules, bathroom modules, kitchen modules, commercial space module, and multipurpose room module. The modules are all based on tiles of 1.4m∗1.4m.

Each module has a value associated with it, this can be equated to the real construction cost of the module. This is a changeable variable that can be assigned at the beginning of the game play.

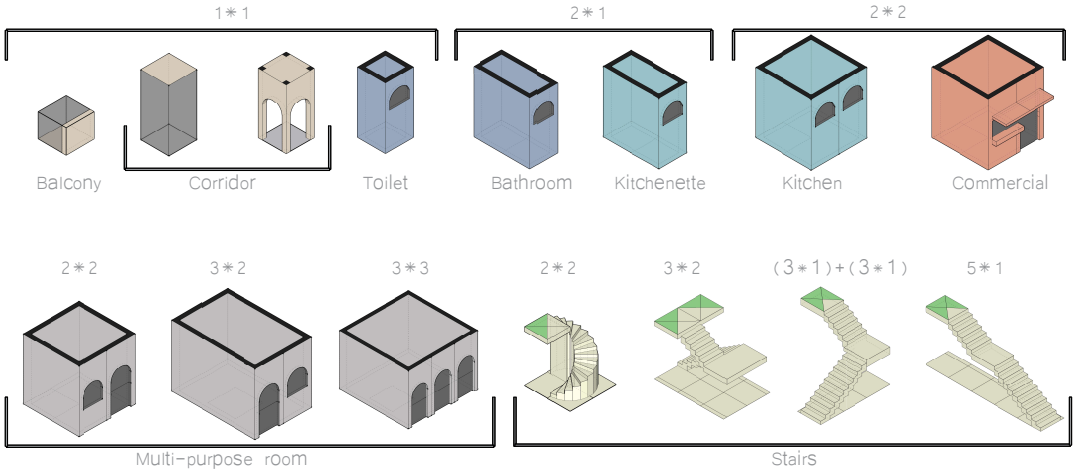


Figure 65: Defined modules. by Author, 2021

Legend of spatial programs in graph representations.

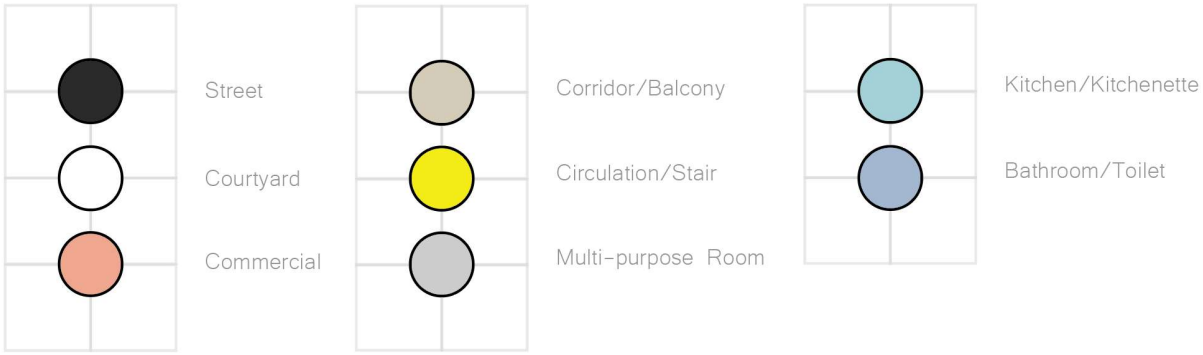


Figure 66: Legend of spatial programs in for graph representations. by Author, 2021

1. Circulation modules

The circulations modules are modules used for horizontal and vertical circulation. These modules are one tile modules. The modules are divided into 3 types that constitute of corridor module, balcony module, and the and the stair module.

a) Horizontal Circulation Modules

The corridor module is used to connect different spaces. The open corridor module is used to connect spaces with the courtyard. The balcony module gives access to different spaces from the vertical circulation (stair).

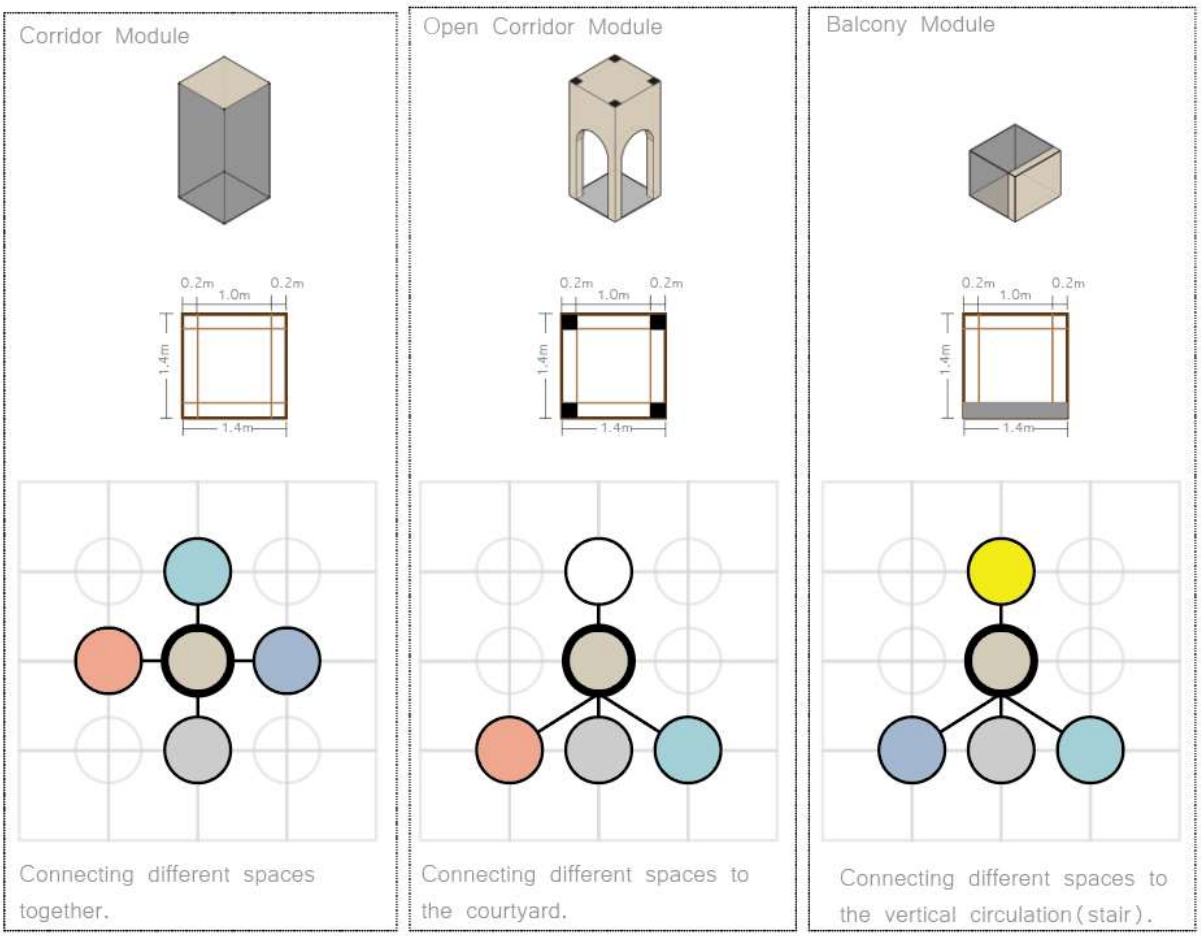


Figure 67: Horizontal circulation modules. by Author, 2021

b) Vertical circulation

The vertical circulation modules are used to give access to different floor levels. These modules are accessed from the courtyard and are connected to the balcony or multipurpose room module.

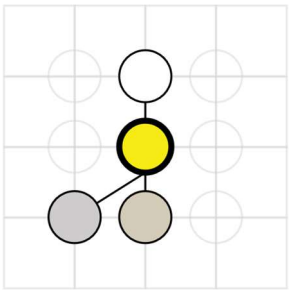


Figure 68: Vertical circulation possible configuration. by Author, 2021

These modules are placed on the shared tiles of the board. Smaller modules make up a stair, these are the step module and the landing module. The step module is a module of 5 steps each with 28cm thread and 18cm riser fitting inside one tile (1.4m ∗1.4m). The landing module acts as one step with 18cm riser and fits with in one tile (1.4m∗1.4m). Each stair has 17 steps to reach the next floor (+ 3.06m). There are 4 different types of stair modules.

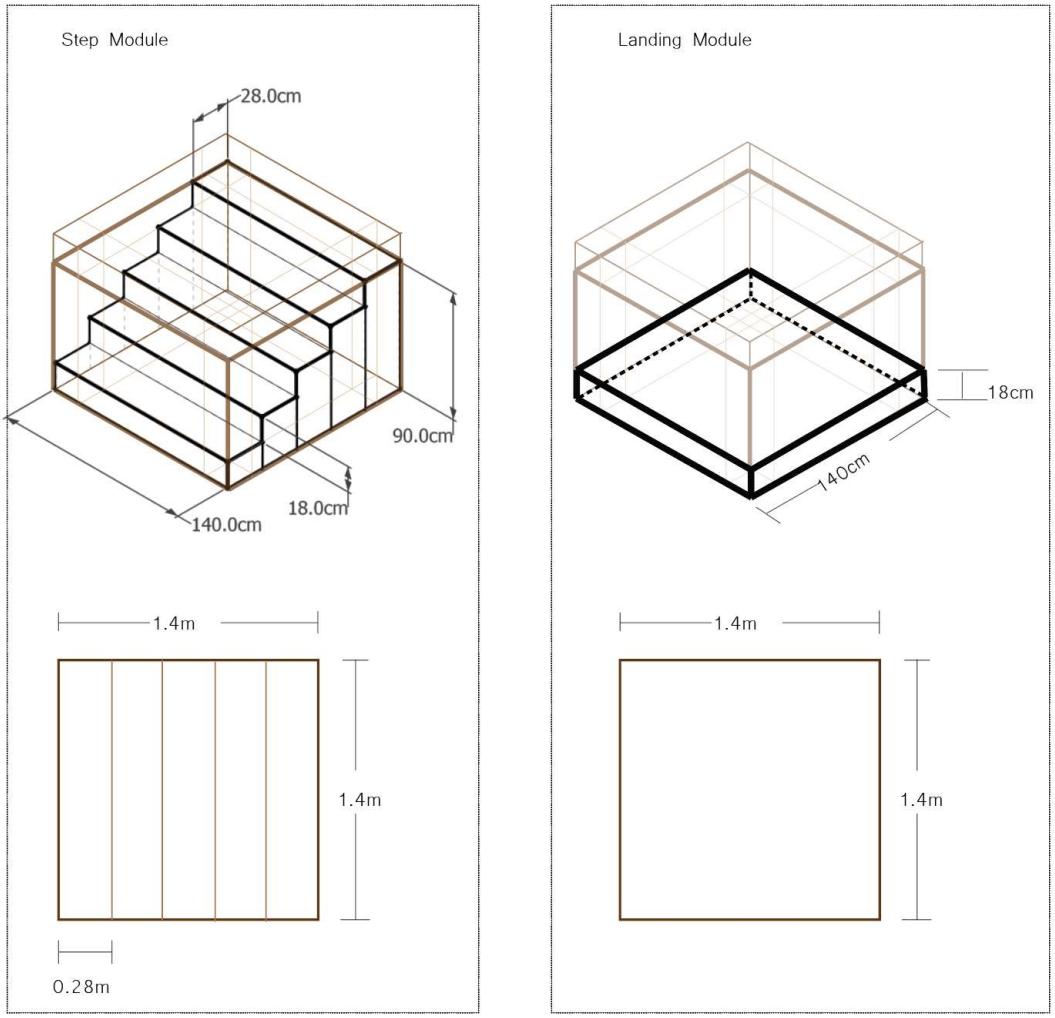


Figure 69: Step and Stair Module. by Author, 2021

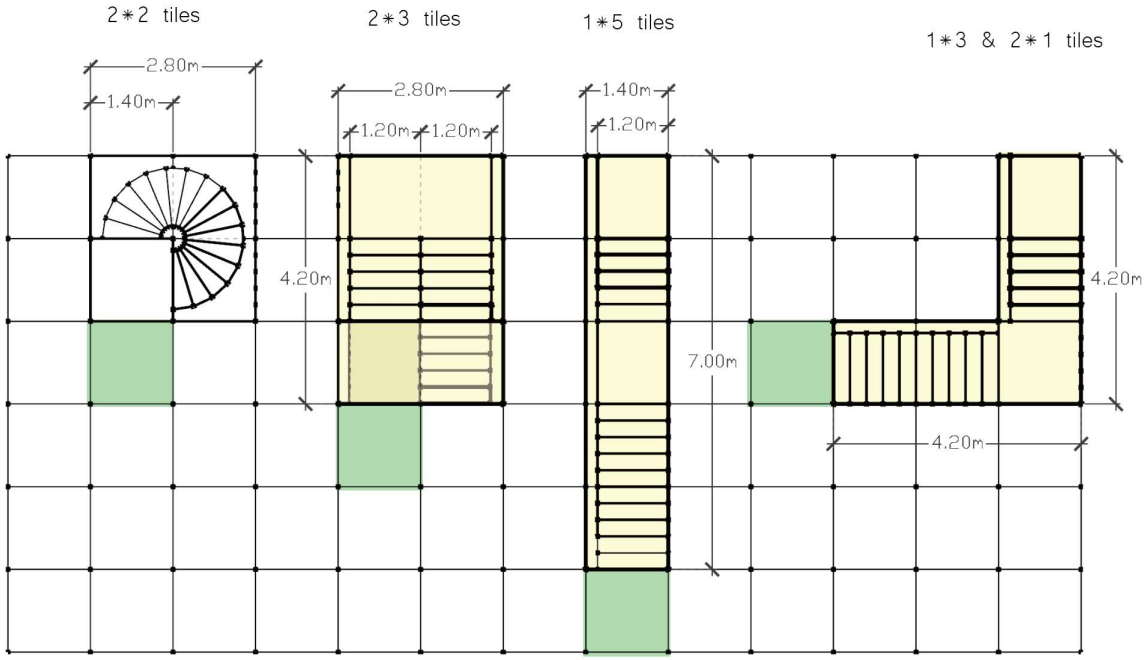


Figure 70: Stair modules plan view. by Author,2021

The access to the stair modules needs to be free and open to the courtyard as indicated in green on the figures.

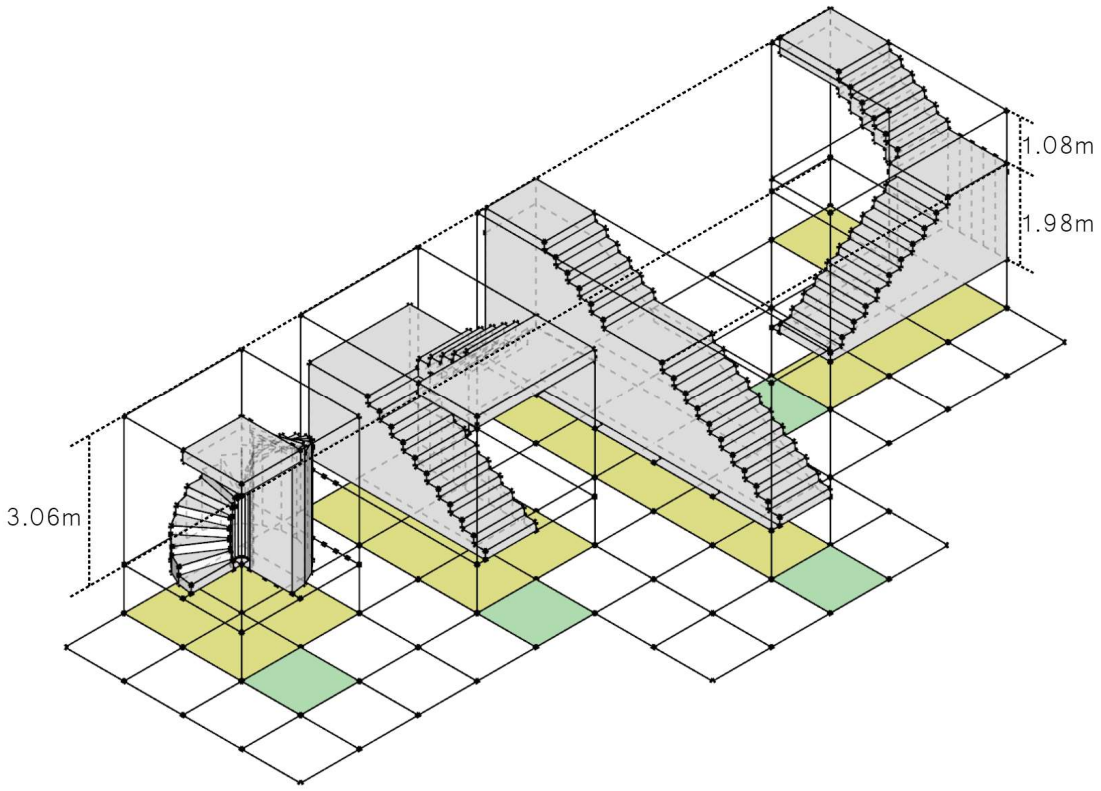


Figure 71: Isometric view of stair modules. by Author, 2021

2. Multi-purpose room module

The multi-purpose room module is a volumetric space that allows players to assign multiple functions to the room. This is based on the study of the kebele houses, where the dwellers use a room for multiple purposes by either changing functions through out the day or placing removable partitions such as curtains to distinguish between two or more functional spaces. In this meta game, three different sizes of a multi-purpose room are defined.

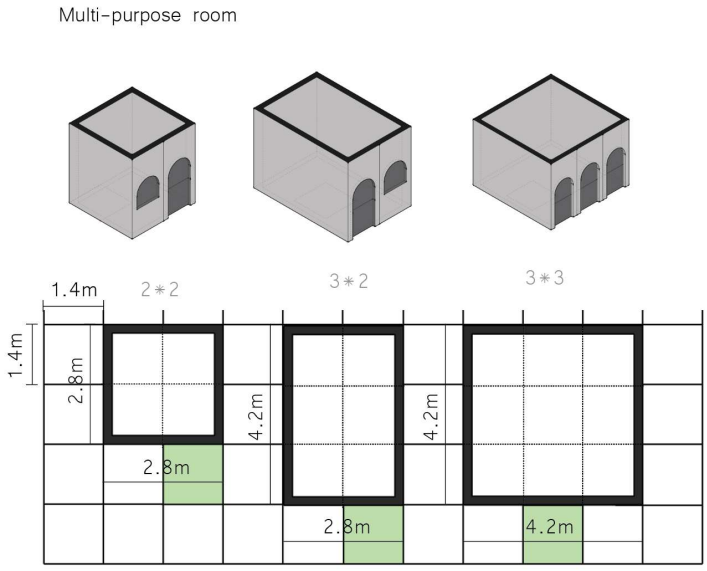


Figure 72: Multi-purpose room module. by Author, 2021

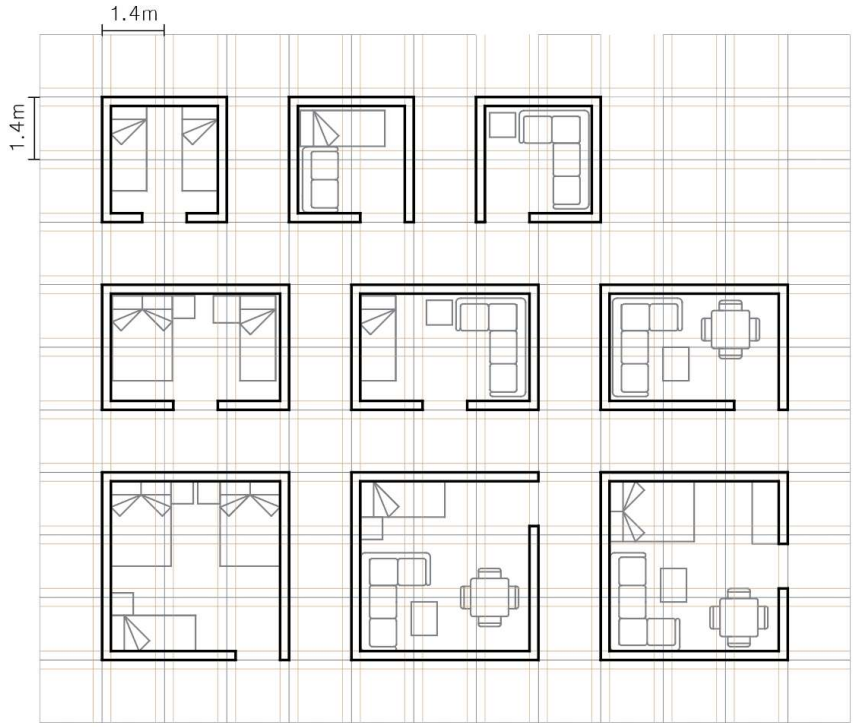


Figure 73: Example of space usage in multi-purpose rooms. by Author, 2021

The multi-purpose room can connect to any room module.

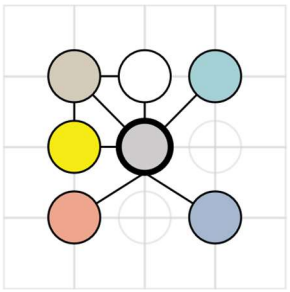


Figure 74: Possible spatial network with multi-purpose room. by Author, 2021

3. Kitchen & kitchenette Module

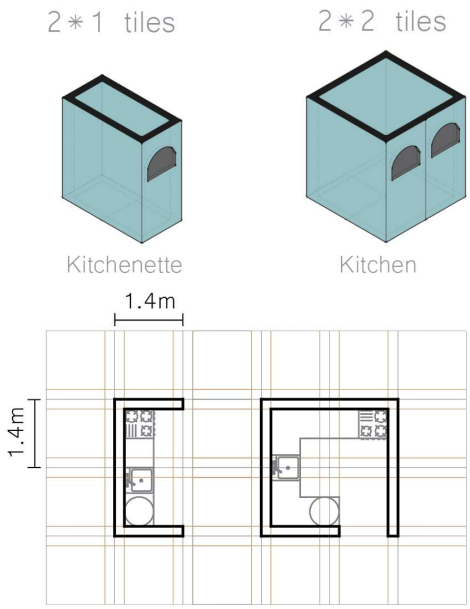


Figure 75: Kitchenette and kitchen modules. by Author, 2021

a） The kitchenette module

The kitchenette module is made up of 1∗2 tiles, where the module is used as a space extender of the multipurpose room. This module always needs to be connected to a multi-purpose room module.

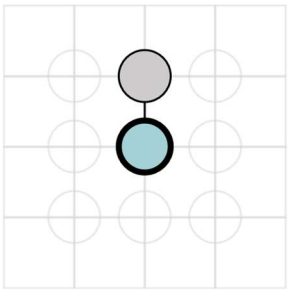


Figure 76: spatial network of a kitchenette module. by Author, 2021

b) The kitchen module

The kitchen module is a 2*2 tile module. This module can be accessed from either a courtyard, a multi-purpose room or from a corridor module.

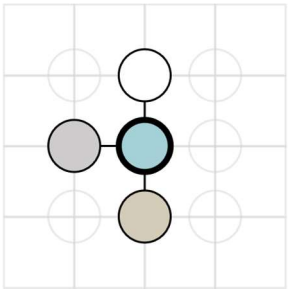


Figure 77: possible spatial network of a kitchen space. by Author ,2021

4. Bathroom and Toilet module

The toilet module is made up of one tile and the bathroom module is made up of 1*2 tile. These modules can be accessed from either a courtyard, a corridor or a multi-purpose room.

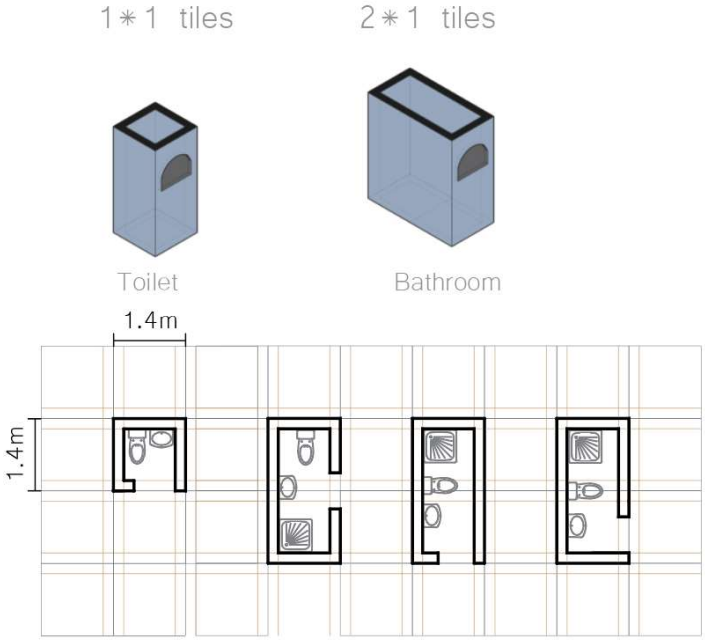


Figure 78: toilet and bathroom module. by Author, 2021

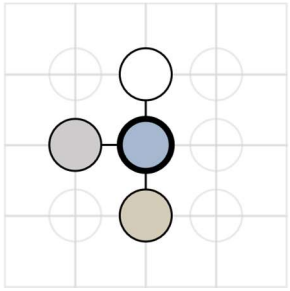


Figure 79: possible spatial network of a bathroom/toilet module. by Author, 2021

5. Commercial Modules

The commercial module is made up of 2∗2 tile. This module needs direct access from the street, in addition it can be connected to a courtyard, a corridor module, a multi-purpose room and toilet module.

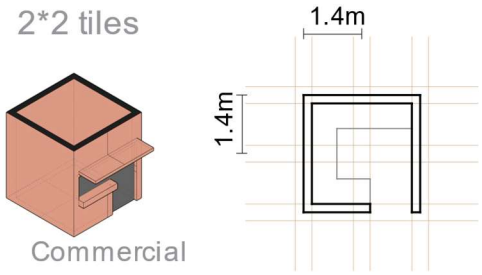


Figure 80: Commercial module. by Author, 2021

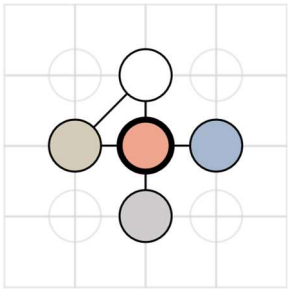


Figure 81: possible spatial network for the Commercial Module. by Author, 2021

Summary of space modules

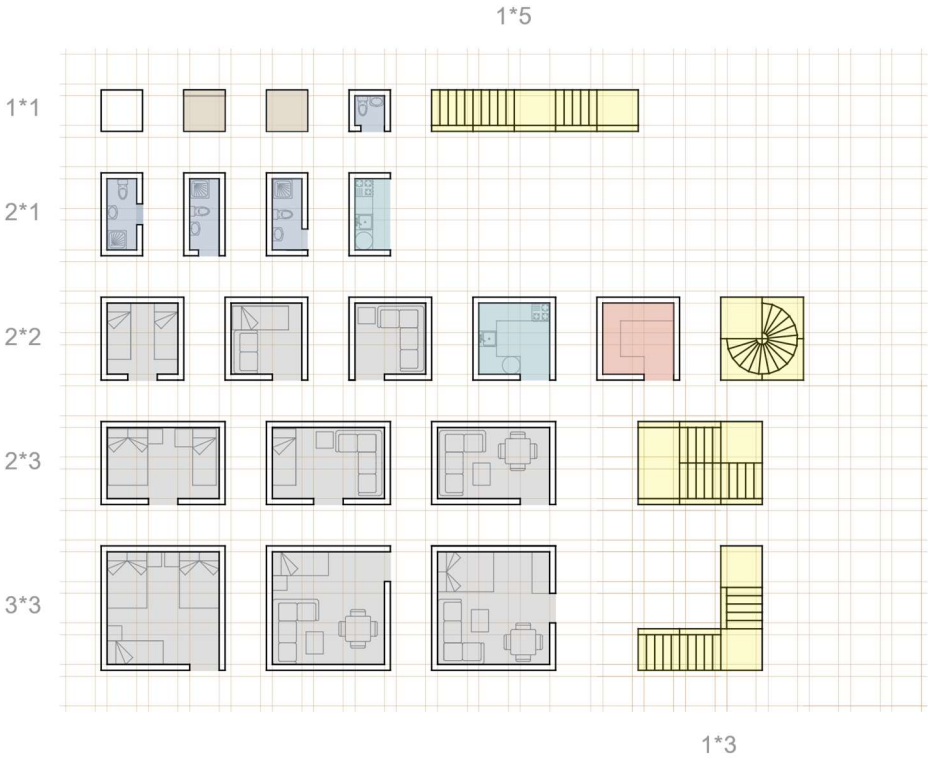


Figure 82: catalogue of modules. by Author, 2021

Forming Level Modules

Wall Modules

Once the spatial configuration is complete, the configured space is modified to include access doors and openings. To aid this process, wall modules are defined with various types and sizes of openings. The users can choose which wall module they would like to use at which location.

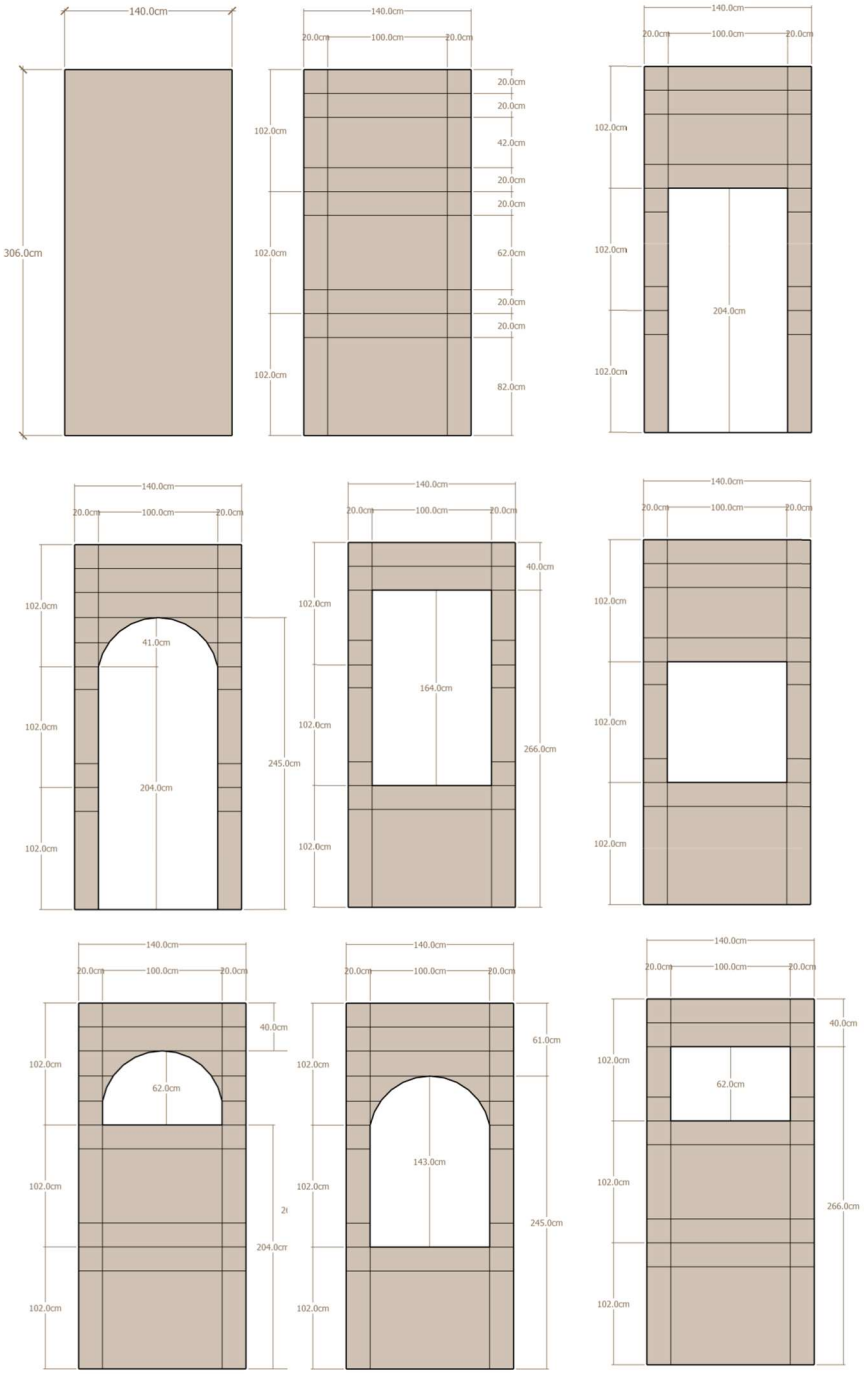


Figure 83: Single wall tile openings. By Author, 2021

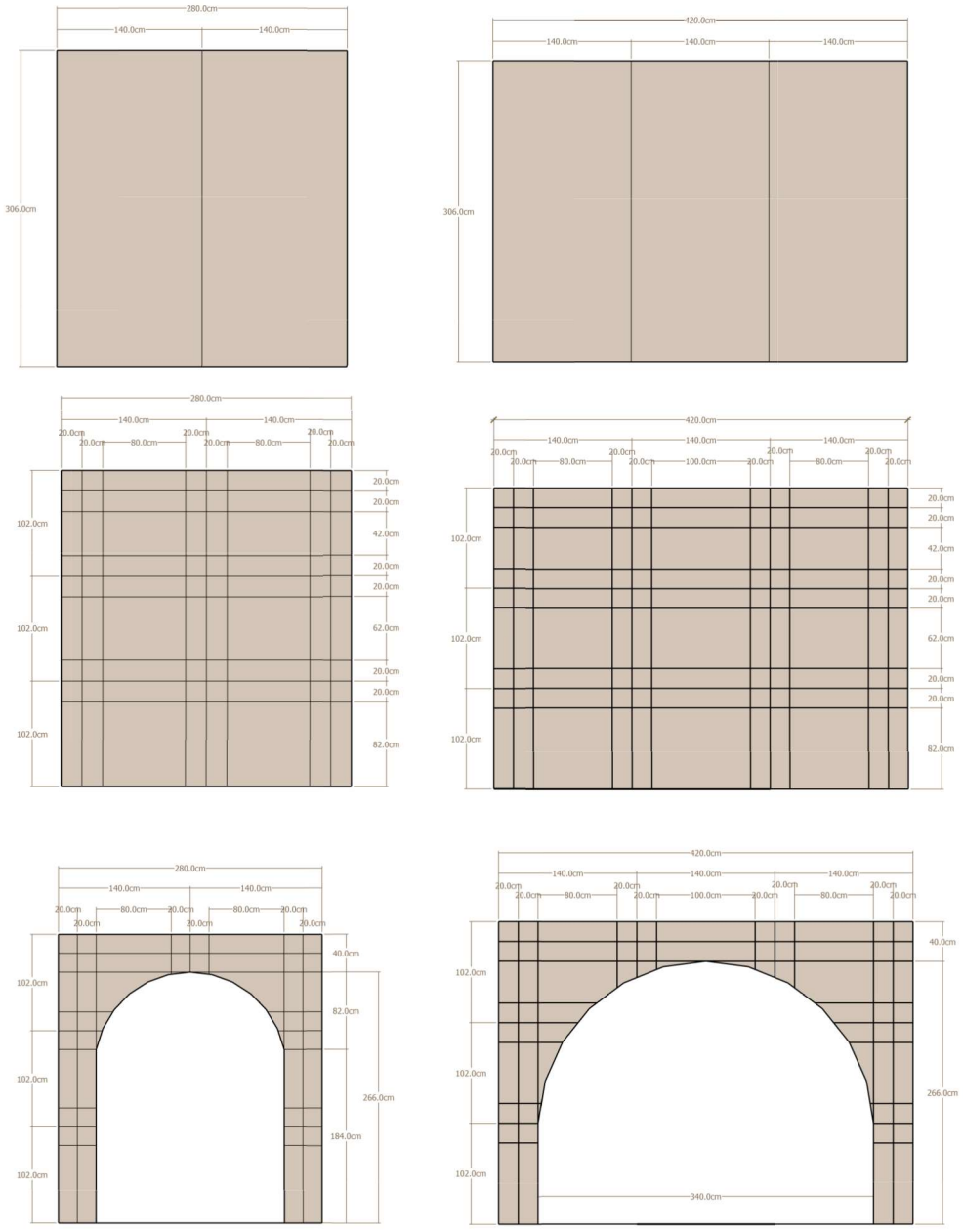


Figure 84: wider opening modules. By Author, 2021

Roof Module

The roof modules are based on a 3-dimentional grid. The roof can be slanted, flat, domed, and vaulted depending on the user's preference. More types of roofs can be defined (apart from those presented here) using the 3-dimentional grid as a starting point.

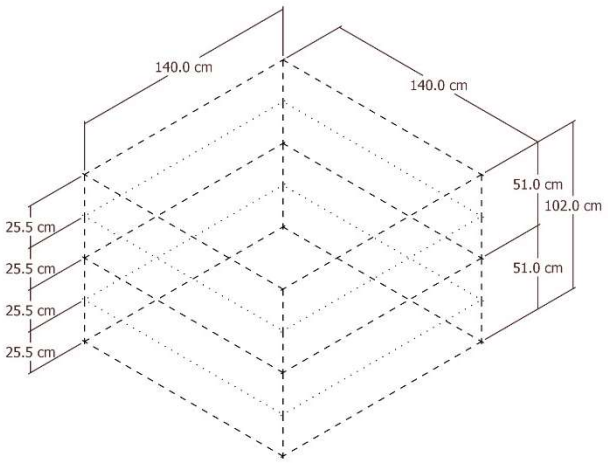


Figure 85: Dimentional system for roof. By Author, 2021

Pitched roof

The pitched roof is based on the following modules, these modules can be combined to form different types of pitched roofs (shade, butterfly, gable, & hip).

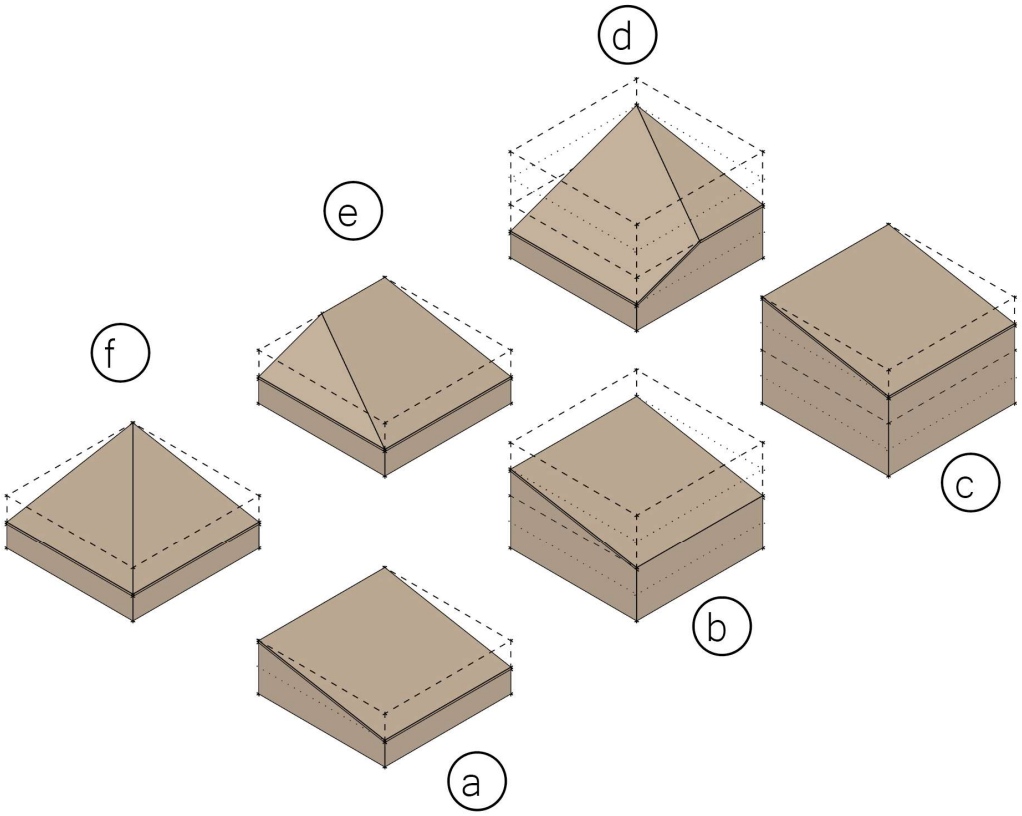


Figure 86: roof modules. By Author, 2021

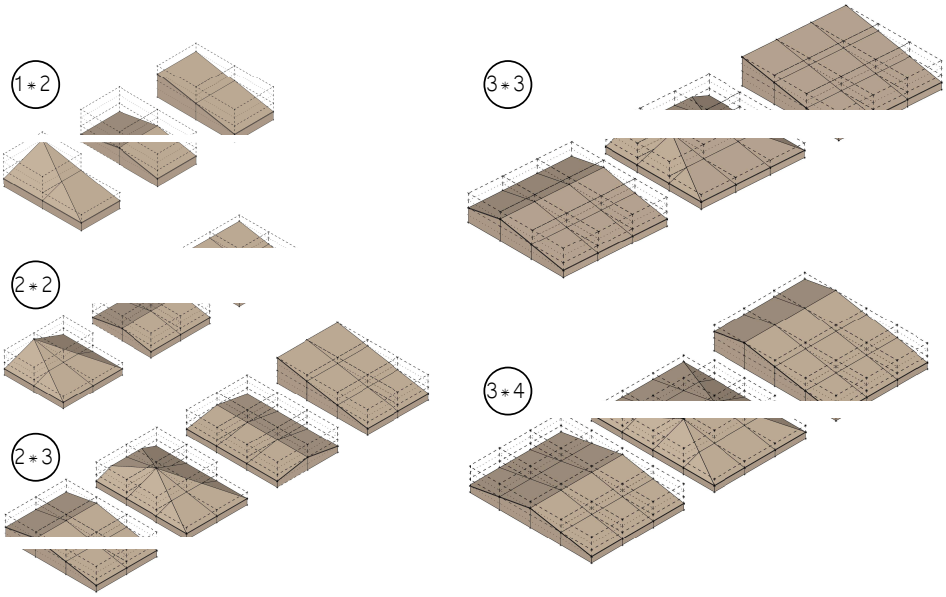


Figure 87:Different types of roofs. By Author, 2021

Vault and dome roof

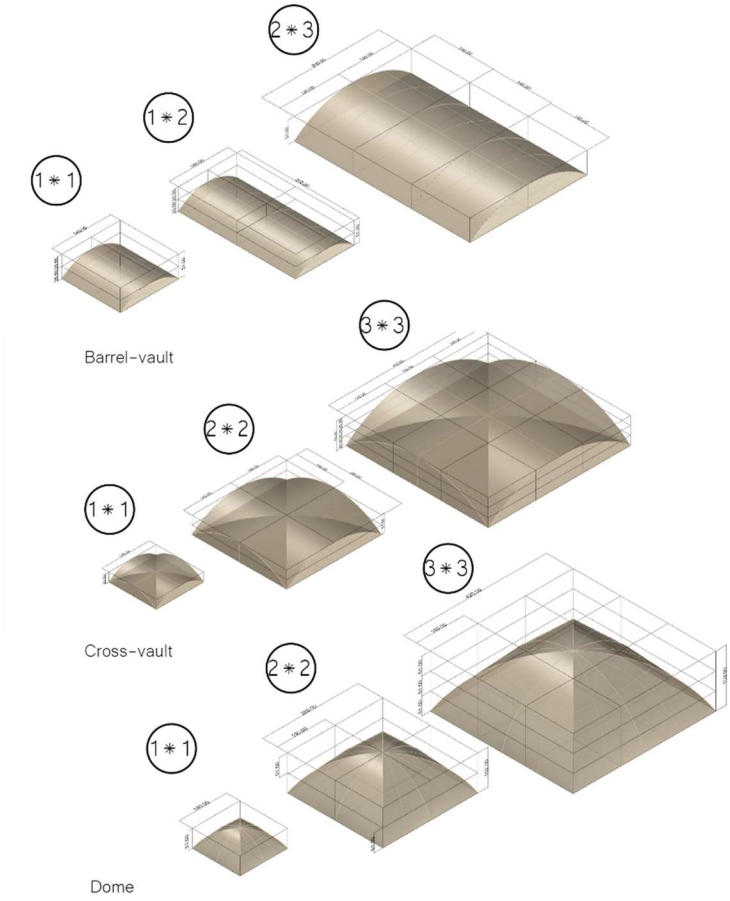


Figure 88: Vault and dome roof. By Author, 2021

4.3.4 Tokens

Tokens are used to acquire modules in the game. Tokens are given to players based on their financial capacity.

Token pool: the token pool is inspired by the iqub. The token pool is when players agree to each contribute a fixed amount of token and the total collected token can be used by each player to acquire more modules. This is considered like a loan system, where the player couldn't immediately afford to pay for a module but can pay for it over a longer period of time.

Figure 89: Token.

4.3.5 Activity cards

Activity cards denote activities that can take place in the shared courtyard space. The players can use the courtyard space as an extension to their houses by selecting activity cards according to their needs and preferences. The number of activity cards a player can select will be determined at the beginning of the game play based on the number of households and courtyard size. The minimum of activity card one player can select is set to three. If the players need an activity card that is not part of the deck, the player can request the game master to include it.

Figure 90: Activity cards. By Author 2021

For every three activity cards a player can select, the player gets one cancel card that can be used to disapprove of an activity card selected by another player. If half or more of the players decide to cancel the same activity, that activity will be removed and cannot be practiced inside the courtyard space.

Figure 91: Cancel activity Card. By Author, 2021

4.4 GAME RULES

GAME RULES

Part One: The Cluster

Input:

: Plot max length & max width
: Number of houses in a compound

Challenge

The challenge is to form a cluster using the 3 different types of boards (Board A, Board B and Board C). The created cluster must have the same number of boards as the number of houses in a compound. The dimensions of the created cluster should be within or in close approximation of the input plot dimensions (plot maximum length and width). Players may refer to the catalogue of clusters and seek help from the game master to complete this challenge.

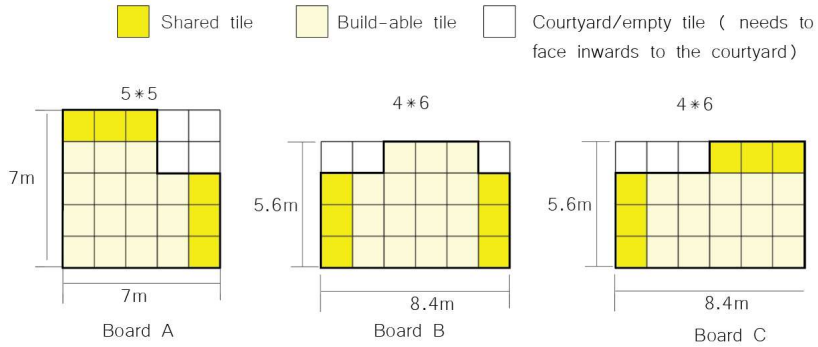


Figure 92: Boards types. By Author, 2021

To form a cluster, join the boards by connecting the shared tiles. The boards can be rotated and mirrored while joining. Board A and Board C can be used to form corners and Board B can be used as a middle piece.

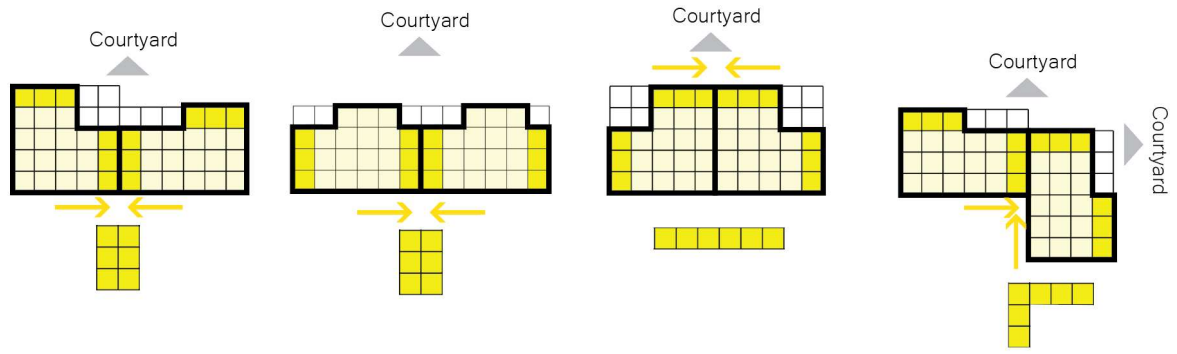


Figure 93: Connecting Boards. By Author, 2021

Sequence of play:

Players pick boards based on their original location and orientation on the plot (when the game is used for upgrading existing compounds). If the game is used for new housing proposals, the players will select their preferred orientation. Players with houses on the corners of the compound can pick between Board A and C. Players in the middle can choose Board B. Alternatively two players can use board A and/or C in the middle by placing them mirrored consecutively; in this case the players may have to share a wall.

Figure 94: Connection possibilities of various board types. By Author, 2021

The player adjacent to the street on the right side of the entrance into the compound starts the play and the play continues in a counter-clockwise manner.

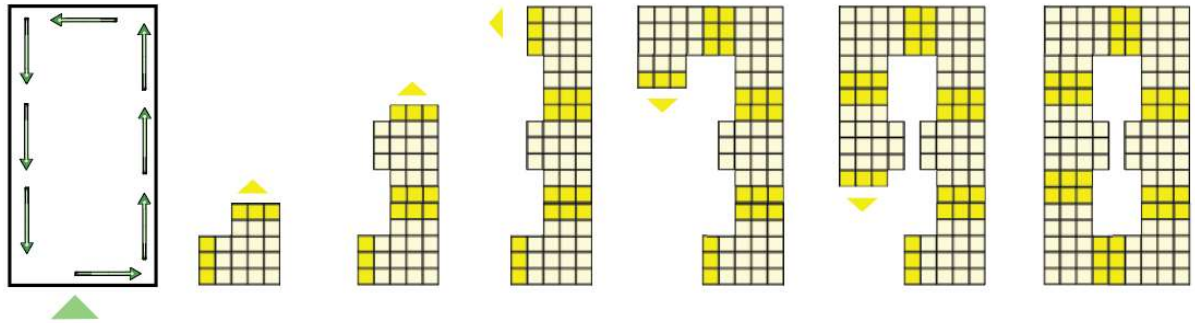


Figure 95: Sequence of play. By Author, 2021

Part Two: The Configuration

Input

: Created cluster

: Tokens

Challenge

The challenge is for the players to configure their houses using the predefined modules by placing them on the build-able and shared tiles of the modules following the configuration rule of each module. The players use their tokens to acquire modules they will like to use. The cost of shared module is shared between players that share the module.

1. The first play in the configuration is to place vertical circulation modules and shared modules. Here neighboring players can decide if they want to place a shared a stair, a private stair, shared modules or leave the space open to allow for light, ventilation and/or access.

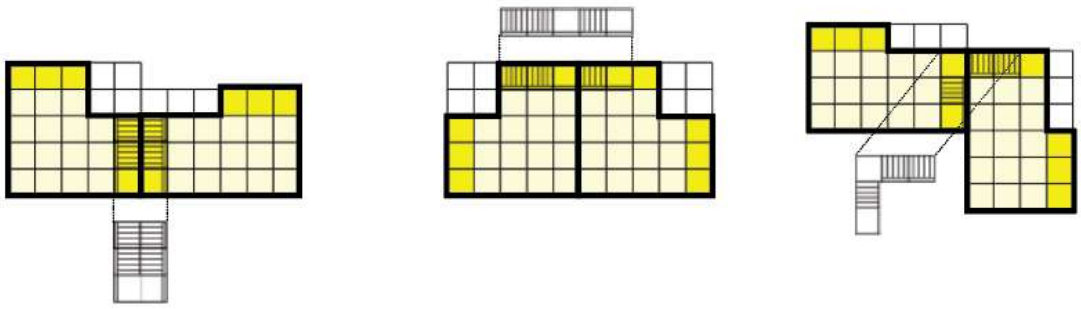


Figure 96: Placing shared modules on shared space on the board. By Author, 2021

2. Once the shared modules are put in place, each player uses the defined modules and places the modules on the build-able tiles of his/her board based on his/her desired configuration. The minimum requirement of one player's house configuration is one multi-purpose room module and a toilet (shared or individual).

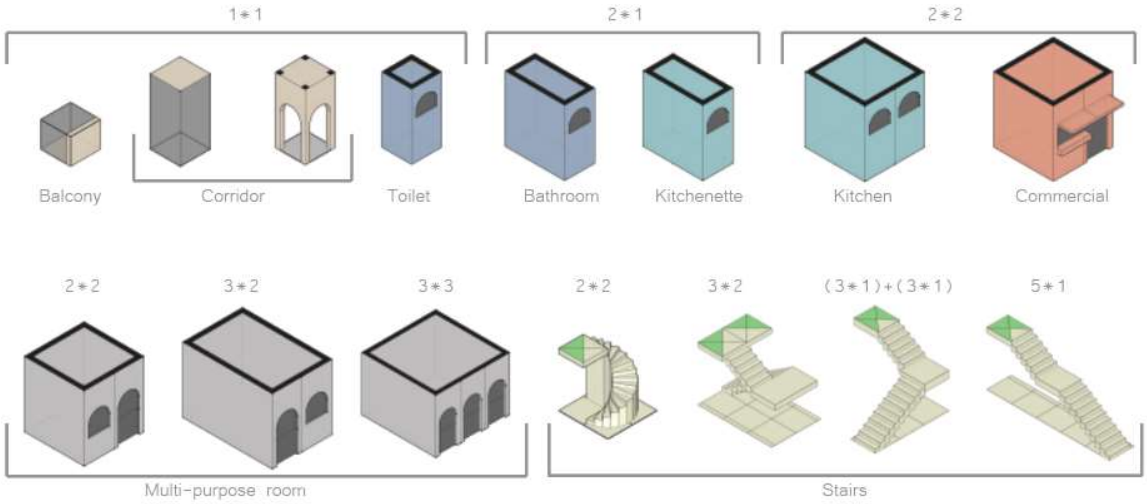


Figure 97: Modules. By Author, 2021

Placing Modules:

A. All the room modules need to have one tile open in-front for light, ventilation and/or access. While placing the modules there should be at-least one opening visible for each module and an open access tile for the stairs.

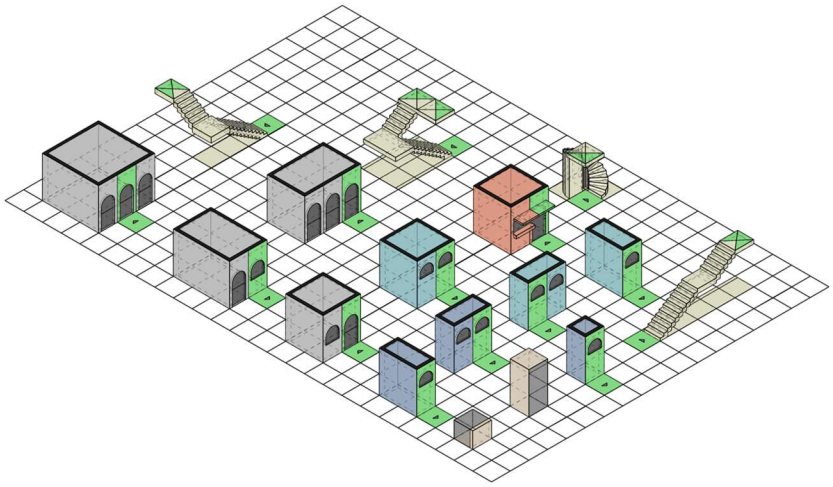


Figure 98: Placing Modules. By Author, 2021

B. Circulation modules

The balcony module can be connected to a stair module or another balcony module.

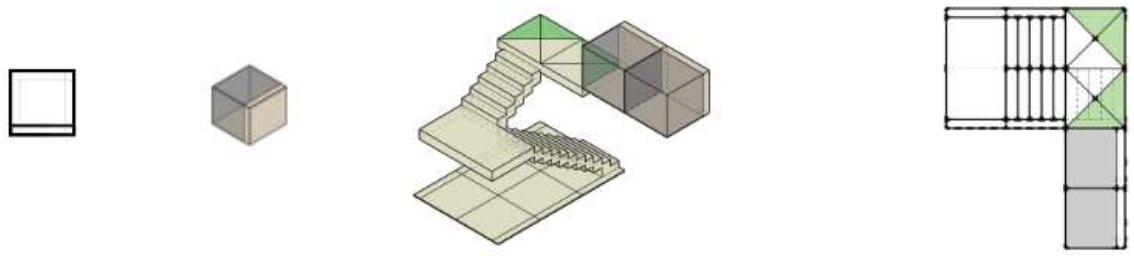


Figure 99: Placing Balcony Modules. By Author, 2021

The corridor module can be placed adjacent to any module and is used to connect different modules.

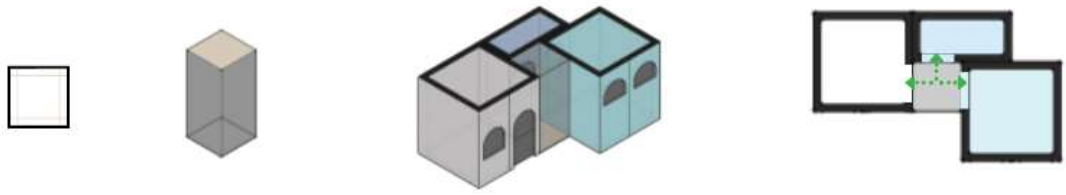


Figure 100: Placing corridor module. By Author ,2021

The open corridor module should be placed facing the courtyard in-front of the entrance to a Multi-purpose room module. It can be placed adjacent to another open corridor module.

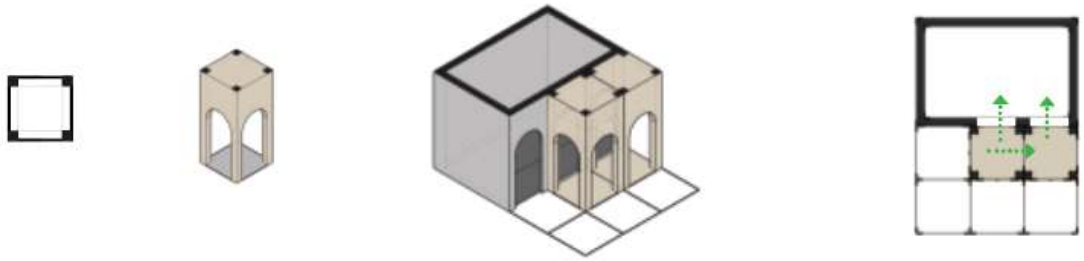


Figure 101: Placement of open corridor module. By Author, 2021

C. Multi-purpose room modules

The Multi-purpose rooms should be placed with access from either the courtyard, an open corridor module, a balcony module or another multi-purpose room module. All modules can be placed adjacent to a multi-purpose room module.

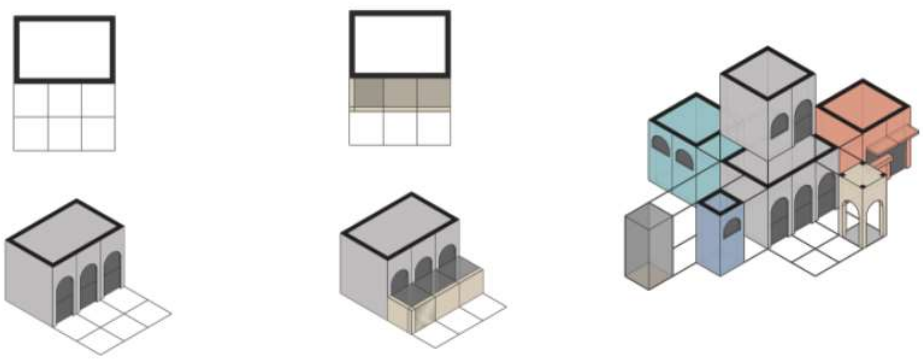


Figure 102: Placing Multi-Purpose room Modules. By Author, 2021

D. Toilet/ bathroom modules

The toilet/bathroom module should be placed adjacent to a corridor module or a multi-purpose room module. This module can only be placed above another bathroom module or kitchen module. Collection of services by making one side of this module adjacent to a kitchen module results in better design.

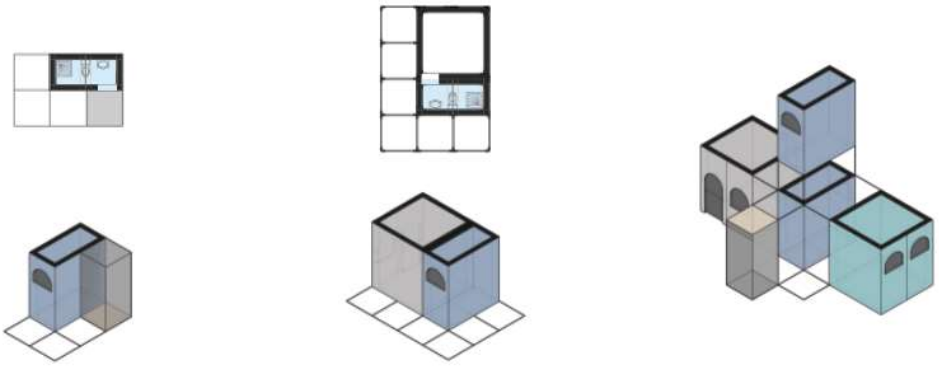


Figure 103: Placement of a toilet/bathroom Module. By Author, 2021

E. Kitchenette and kitchen modules

The kitchenette module can only be placed adjacent to a multi-purpose room module. The kitchen module should be placed adjacent to a corridor module or a multi-purpose room module. This module can only be placed above another bathroom module or kitchen module. Collection of services by making one side of this module adjacent to a bathroom module results in better design.

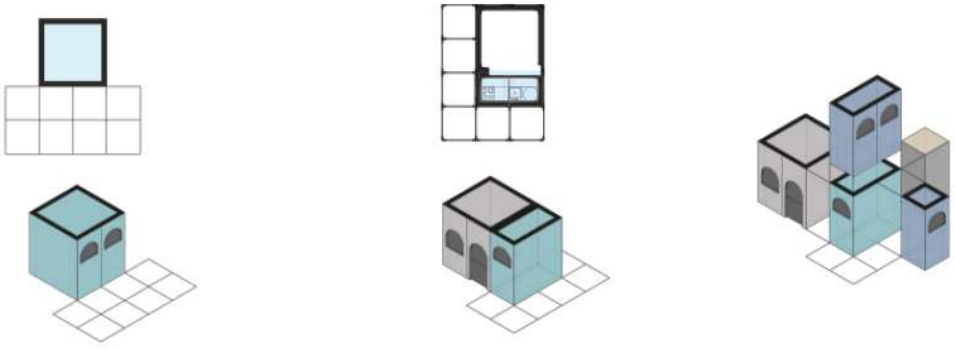


Figure 104: Placement of Kitchen Modules. By Author, 2021

F. Commercial module

One side of the commercial module must always be placed facing the street. All other modules can be placed adjacent to the commercial module.

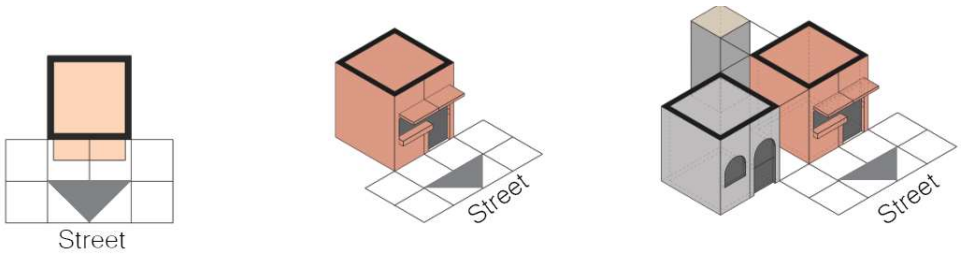


Figure 105: Placement of a commercial Module. By Author, 2021

Token pool

If players want to acquire modules that they currently can't afford, they can enter the token pool. The players each contribute a fixed number of tokens (determined by the players) and the total amount of tokens collected can be used by each player to acquire more modules.

Choosing activity cards

Once the players have configured their space. They can choose activity cards (minimum of 3, Maximum to be set at the start of the game) based on which activities they would like to do in the courtyard space. Each player gets one 'cancel activity' card per three activity cards they select. They can use this cancel cards to disapprove activity cards chosen by other players. If half the players cancel the same activity, then that activity will be removed.

Part Three: Forming

Once the configuration is complete, the players can select the type, size and position of walls and openings from the wall modules. They can select the type of roof they would like to use from the roof modules.

Validity check

1. The cluster is formed by connecting the shared tiles of the boards (Board A, B and C)

2. The number of boards forming a cluster is the same as the number of houses in a compound.

3. The size of the formed cluster is within or it is the closest approximation to the maximum length and width of the plot.

3. Shared modules and stairs are only placed on the shared tiles of the boards.

4. Every room module has at-least one face tile with an opening for light, ventilation and/or access.

5. Open corridor modules should be placed facing the courtyard.

6. The multi-propose room is either directly accessed from the courtyard or from an open corridor module, a corridor module, a balcony module or another multi-purpose room.

7. Bathroom/toilet and kitchen modules can only be placed above another bathroom/toilet/ or kitchen module.

8. The kitchenette module always needs to be connected to a multi-purpose room.

9. The Commercial module is placed facing the street.

4.5 ROLE OF THE GAME MASTER

The gamemaster prepares the game session for the players and describes the events taking place. The game master acts as a facilitator by explaining the game play rules, the game elements and required players' decisions. The game master allocates tokens to players. The players can seek help from the game master in the configuration process. If required, the gamemaster can add or amend rules in the play process. The gamemaster can add modules and activity cards based on the modular coordination system if requested by players. The game master oversees the play process, and checks the validity of the players' configurations.

4.6 PRODUCT DESIGN: GAME MODULES

The modules are modeled in rhino at a 1:100 scale and 3D printed so they can be used as physical props representing volumetric spaces in the game play. The room modules are modeled like a Lego, where they can be stalked vertically.

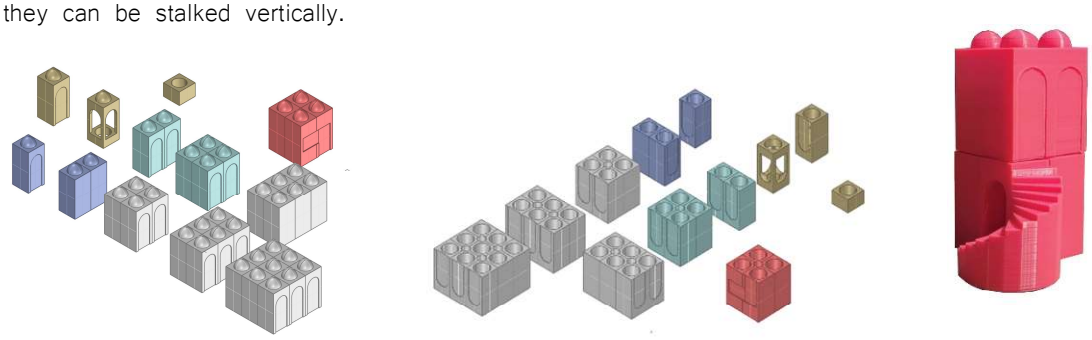


Figure 106: Modules for 3D print

The stair modules are modeled in a way to be easily 3d printed using less material and no support. The stair models are placed sideways as shown in the second image below for ease of printing.

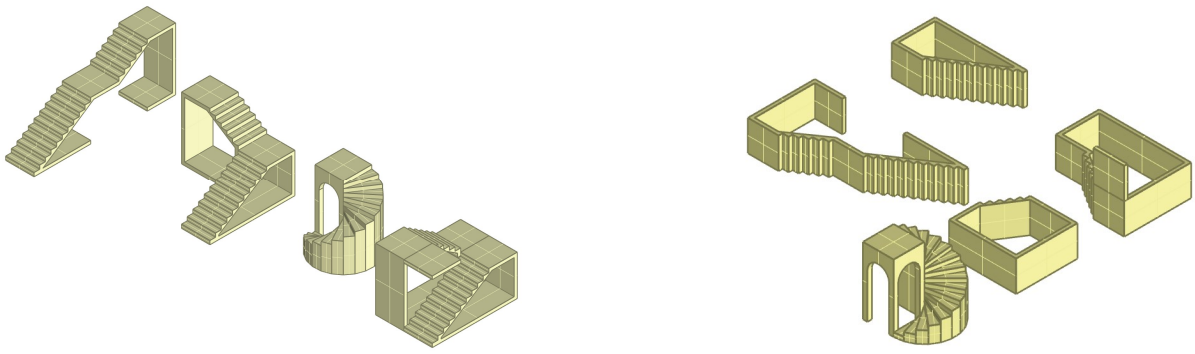


Figure 107: stair modules for 3d print

REFERENCES

Addis Ababa Structural Plan 2017-2027.pdf. (2017). AACPPO.

CHAPTER V

5 CHAPTER 5- DEMO: TEST CASE

5.1 DEFINING THE TEST CASE

For the purpose of the study a kebele house with 8 households located in Kirkos sub-city, woreda 4, kebele 38 was studied. The size of the households' range between 4-6 people.

Figure 108: Sketch plan of Kebele compound. by: Author, 2021

Household One has a household size of 5 people. The house is essentially one room subdivided by curtains to distinguish between the living space, the sleeping space and the cooking space. The household shares a Kitchen with 2 other households and a bathroom with 7 other households.

Household Two has a household size of 4 people. The house has one room that serves triple function of living/dinning space, sleeping space and storage space. There is an added flooring above the room forming an attic space that is accessed by a ladder used as a sleeping space. The household shares a kitchen with 2 other households and a bathroom with 7 other households.

Household Three is a one room house with a dual function of living space and sleeping space distinguished using curtains. The household size is 4 people. The household shares a kitchen with 2 other households and a bathroom with 7 other households.

Household **one**, **two** and **three** have the same spatial configuration. Rooms serving multiple functions are noted as multi-purpose rooms.

Figure 109: graph representation of configuration of house 1, 2 and 3.

Household Four is a 3-room house with a living room, another room with dual function of cooking space and sleeping space. The final room is a storage space. The household size is 4 people. The household shares a bathroom with 7 other households.

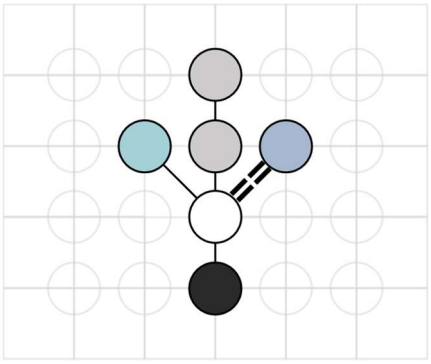


Figure 110: graph representation of configuration of house 4.

Household Five is a 3-room house with a household size of 4 people. There is a room with dual function of living space and cooking space separated with a curtain. There is another room that is a bed room with bunk beds. The final room is a newly constructed private toilet exclusive to this household only. The

household also shares a kitchen/storage space with one other household and shares the bathroom with 7 other households.

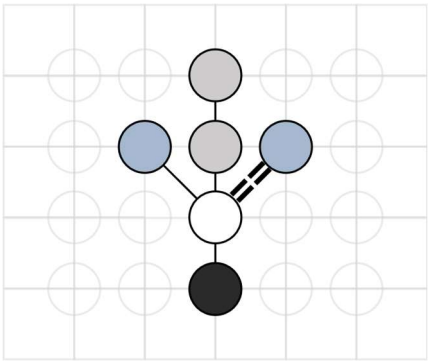


Figure 111 : graph representation of configuration of house 5.

Household Six is a 4-room house that is shared by two families with a collective household size of 6 people. There are two bedrooms and a room with triple function of living, dinning and sleeping space. There is also a small kitchen/storage room. The household also shares a bigger kitchen/storage space with another household. The bathroom is shared with 7 other households.

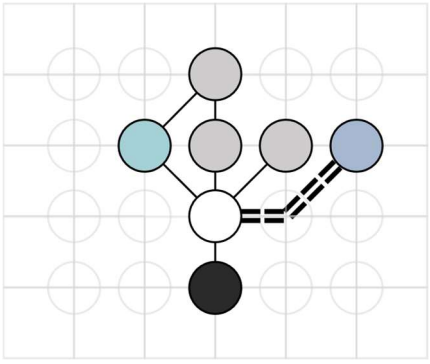


Figure 112:: graph representation of configuration of house 6.

Household Seven is a 2-room house with a household size of 5 people. The first room is a living/dining and sleeping space. The second room is a detached private kitchen/storage space. The household shares a bathroom with 7 other households.

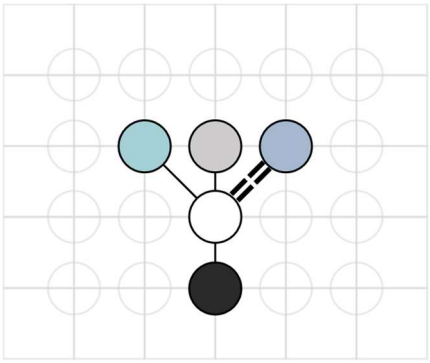


Figure 113: graph representation of configuration of house 7.

Household Eight is a two-bedroom house where the smaller bedroom is a detached room that has a bunk bed. There is a living room/ dining room directly accessed from the alley leading to the courtyard. The larger bedroom is accessed through the living room. The household size is 5 people. The dwellers in household 1 have their own kitchen/storage space but they share a bathroom with 7 other households. While the detached smaller bed room and kitchen are constructed using mud and corrugated iron sheet. The living room/dining room and Larger bed room are newly renovated using hollow concrete blocks.

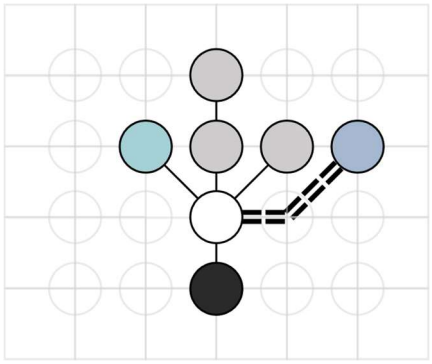


Figure 114: : graph representation of configuration of house 8.

There are two shared kitchens in the compound and there is one bathroom shared by all the households in the compound.

The game is demonstrated on three levels. The fist level is the cluster level, the second is the configuration level and the third level is the forming level. In the game play process, the players use boards, tokens, modules, activity cards and configuration rules. For the purpose of this play the following values are given to the modules. Assigning value to the modules creates a trade-of where the players will have to select modules that they need that is within their financial capability. The values assigned below is for the purpose of the demo, this value is a variable that can be changed in a different play.

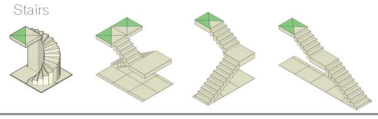
Stairs 	6 tokens	Kitchen 	12 tokens
Balcony 	1 token	Commercial 	12 tokens
Corridor  Corridor 	1 token	Multi-purpose room 	8 tokens
Toilet 	2 tokens	Multi-purpose room 	12 tokens
Bathroom  Kitchenette 	6 tokens	Multi-purpose room 	18 tokens

Figure 115: Cost of each module in tokens.

Tokens are given to the players based on their financial capacity. For the purpose of this demo, the following tokens are given to the households.

	Tokens		Tokens
Player 1	58	Player 5	58
Player 2	30	Player 6	62
Player 3	62	Player 7	50
Player 4	64	Player 8	61

Table 7: Token of each player.

5.2 LEVEL ONE: THE CLUSTER

The players form a cluster of eight using the boards A, B, and C. The player on the right side of the entrance to the courtyard starts the play and the play continues in counter clockwise direction to form the cluster.

Input:

Number of households: 8

Plot: 17m * 26m

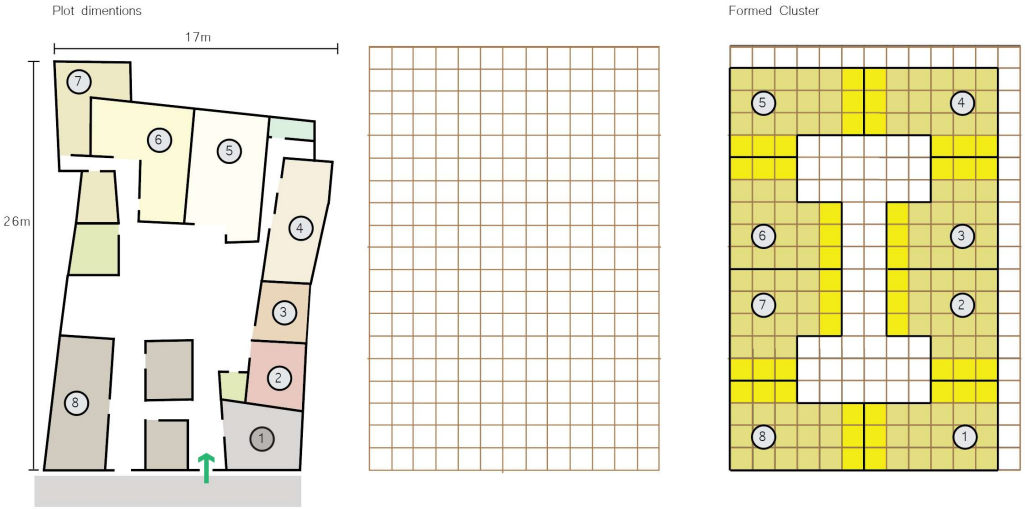


Figure 116: Forming a cluster using plot dimensions.

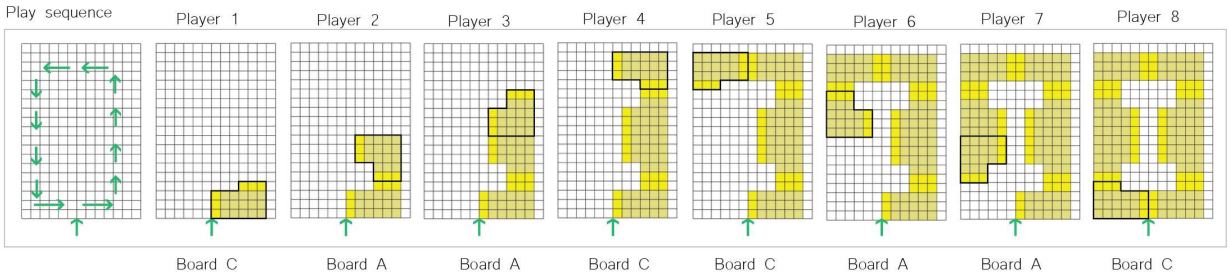


Figure 117: sequential play of forming a cluster.

5.3 LEVEL TWO: THE CONFIGURATION

The first play in this configuration is to place shared modules. Neighboring households decide whether they would like to share a module. Players that choose to play shared modules, split the cost of the shared module. If a player wants to place a private stair, the player acquires the module and pays half the cost of the module to the neighbor. Player one placed a private stair. Therefore, covers the full cost of the stair module (6 tokens) and gives player 2 half the cost of the module for occupying the shared tiles on the board (3 tokens given to player 2). Player two is not sharing any modules (+ 3 tokens from player 1). Player three shares a stair module with player 4 therefore split the cost of the module with player 4 (- 3 tokens). Player 4 shares a stair module with player 3 and a kitchen module with player 5 (- 3 tokens for half the cost of the stair module plus -6 tokens for half the cost of the kitchen module.) Player 5 shares a kitchen module with player 4 and places a private stair (-6 tokens for kitchen module, -6 tokens for stair, - 3 tokens paid to player 6 for occupying shared space for private used). Player 6 uses a private stair (+3 tokens from player 5, -6 tokens for the stair, - 3 tokens paid to player 7 for placing a private stair on shared space). Player 7 shares a stair with player 8 (+3 tokens from player 6, -3 tokens for shared stair). Player 8 shares a stair module with player 7 (-3 tokens).

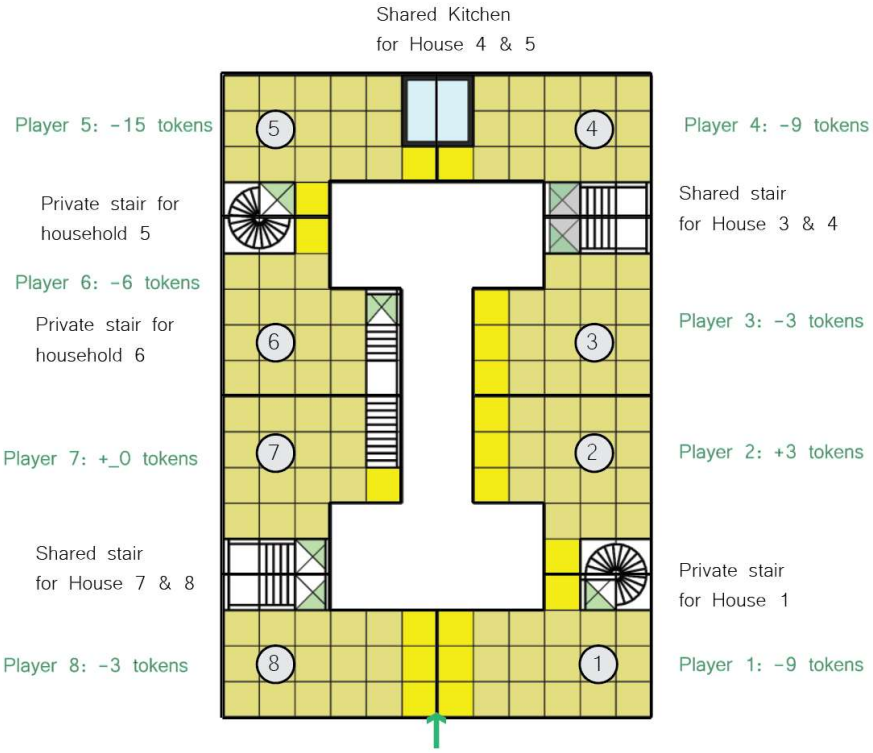


Figure 118: shared module play. By Author, 2021

Once the shared modules are placed, the players use their tokens to get room modules and configure their space.

	Tokens		Tokens
Player 1	49	Player 5	43
Player 2	33	Player 6	56
Player 3	59	Player 7	50
Player 4	55	Player 8	58

Figure 119: Remaining tokens after placing shared modules.

Configuration steps of house Eight by player 8

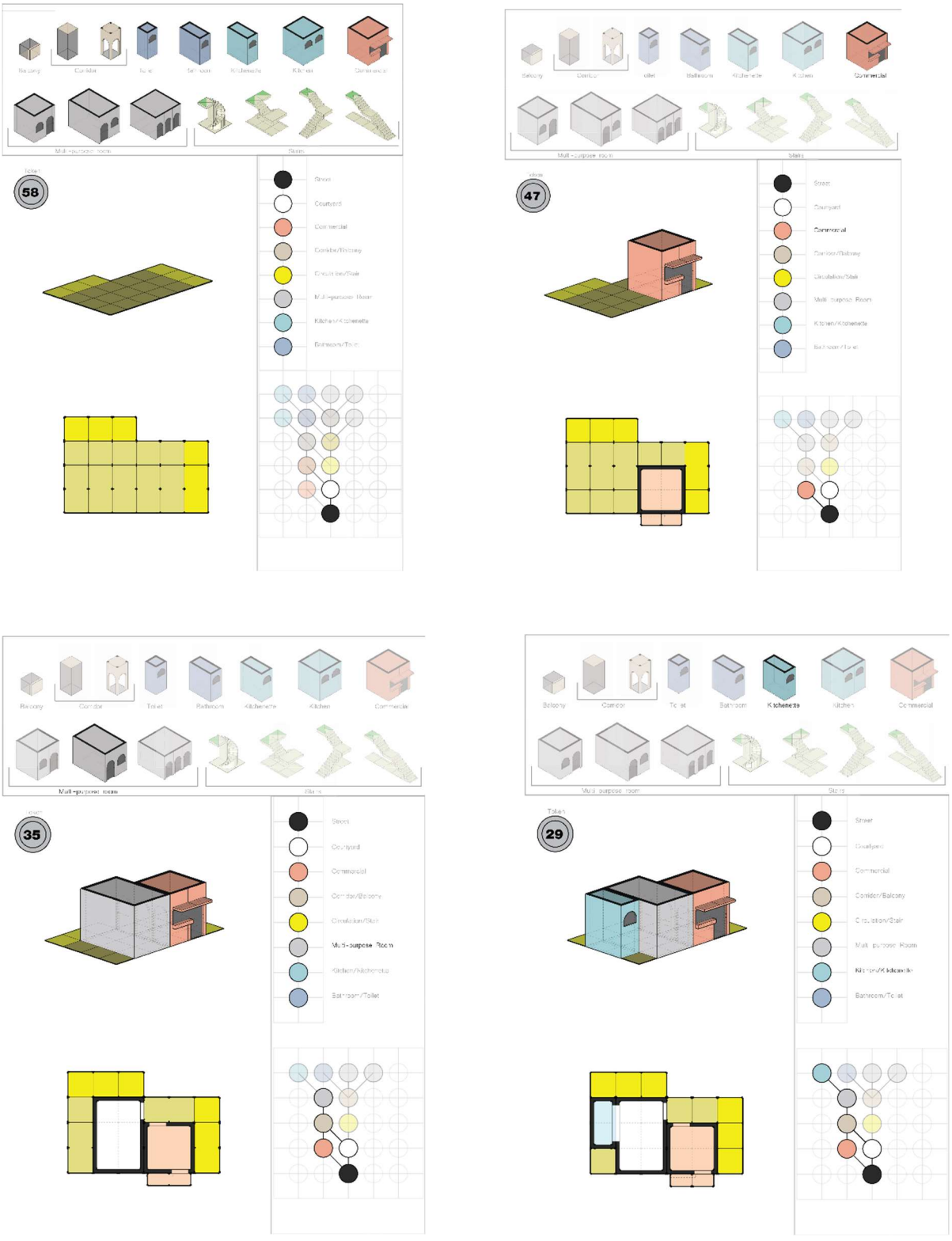


Figure 120: configuration of house 8. By Author, 2021

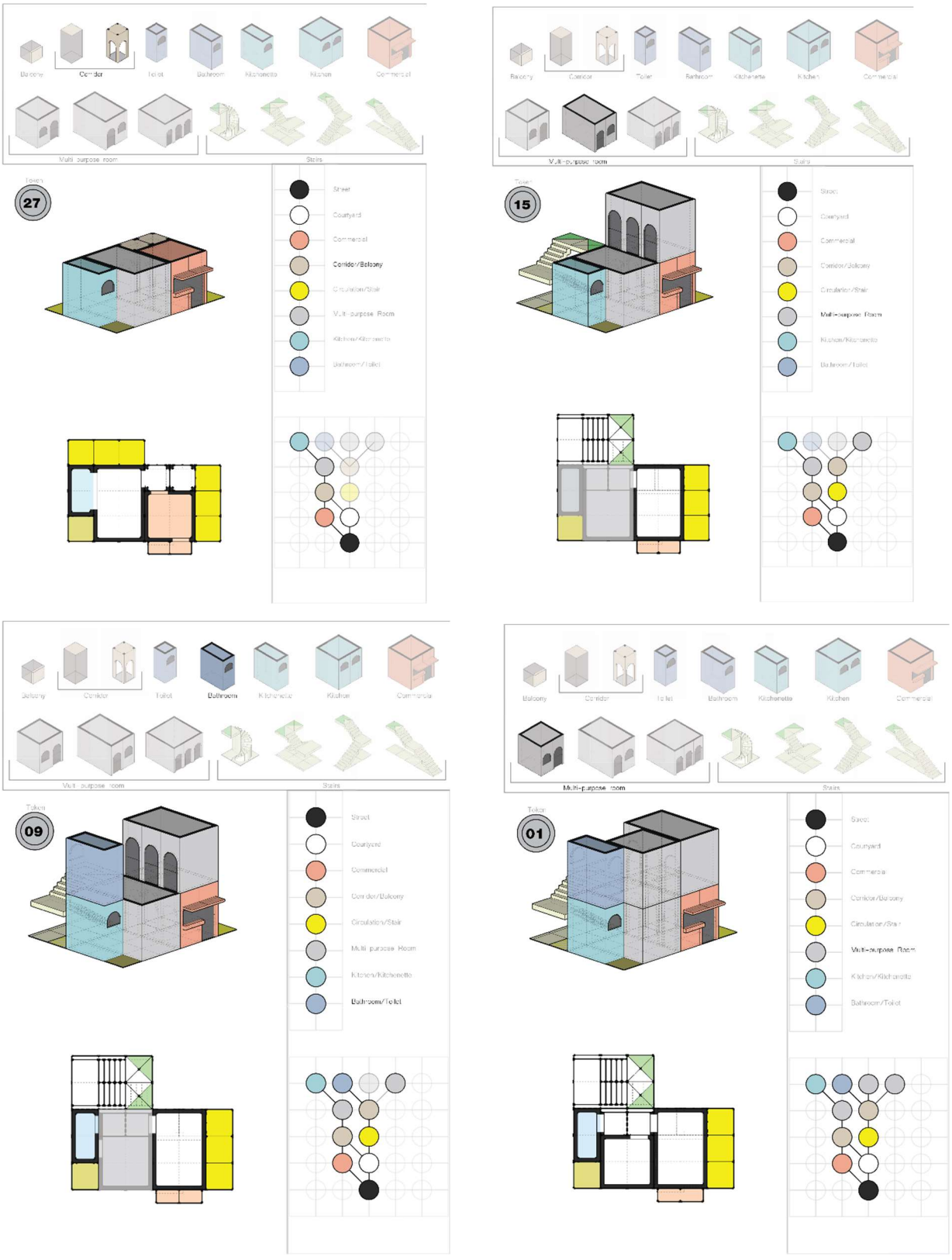


Figure 121: configuration of house 8. By Author, 2021

Configuration of all houses (1-8).

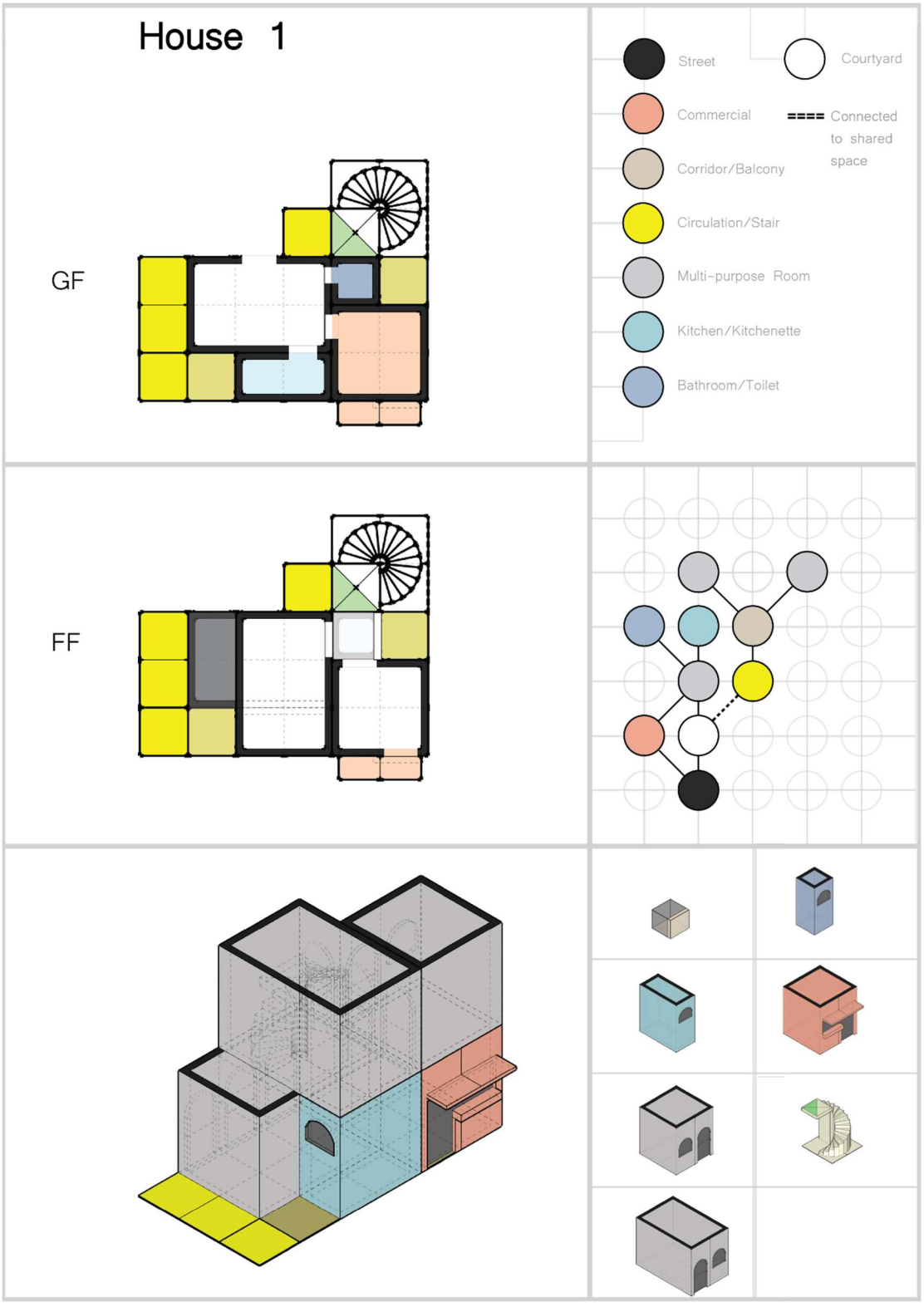


Figure 122: House 1 configuration. By Author, 2021

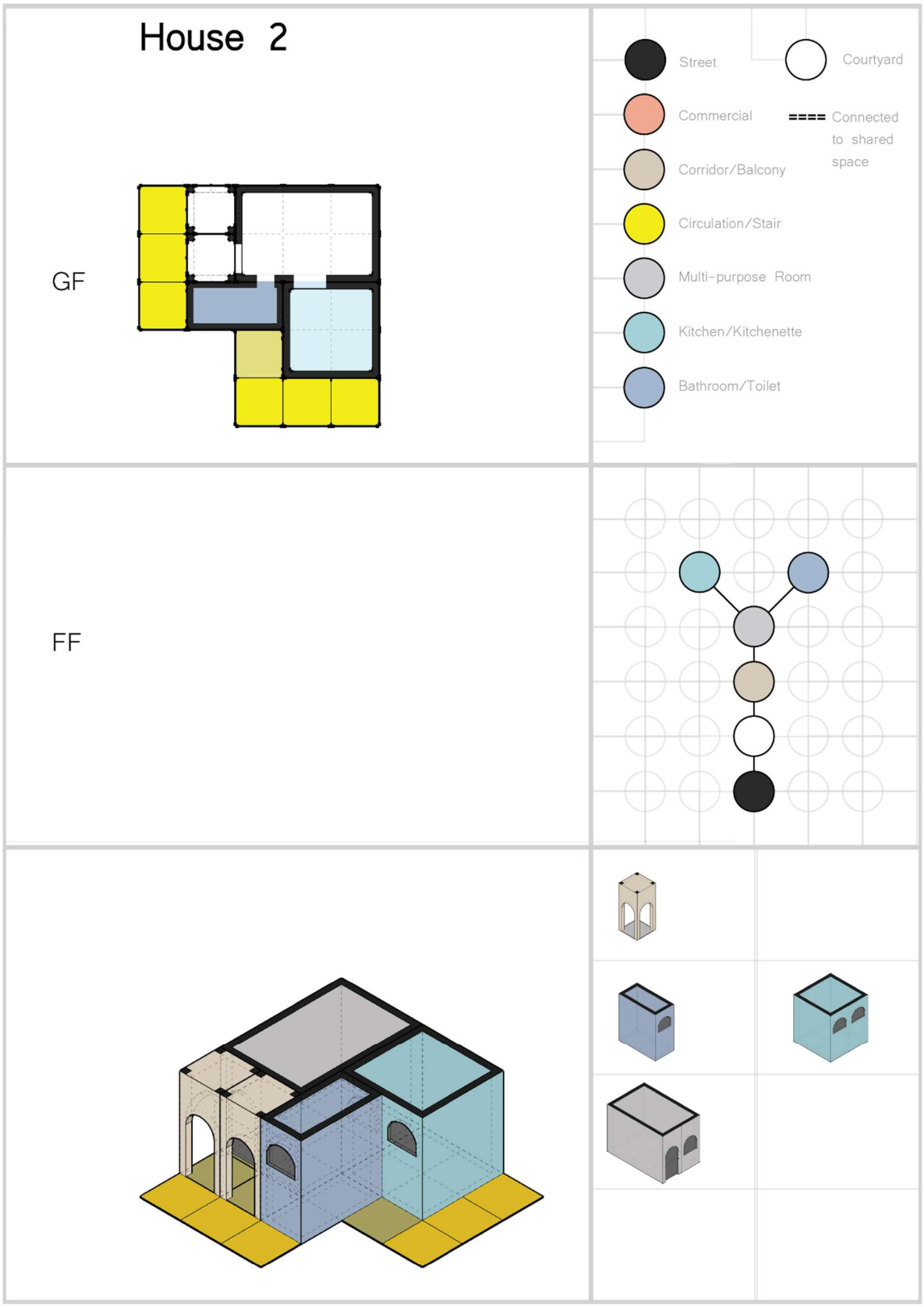


Figure 123: House 2 configuration. By Author, 2021

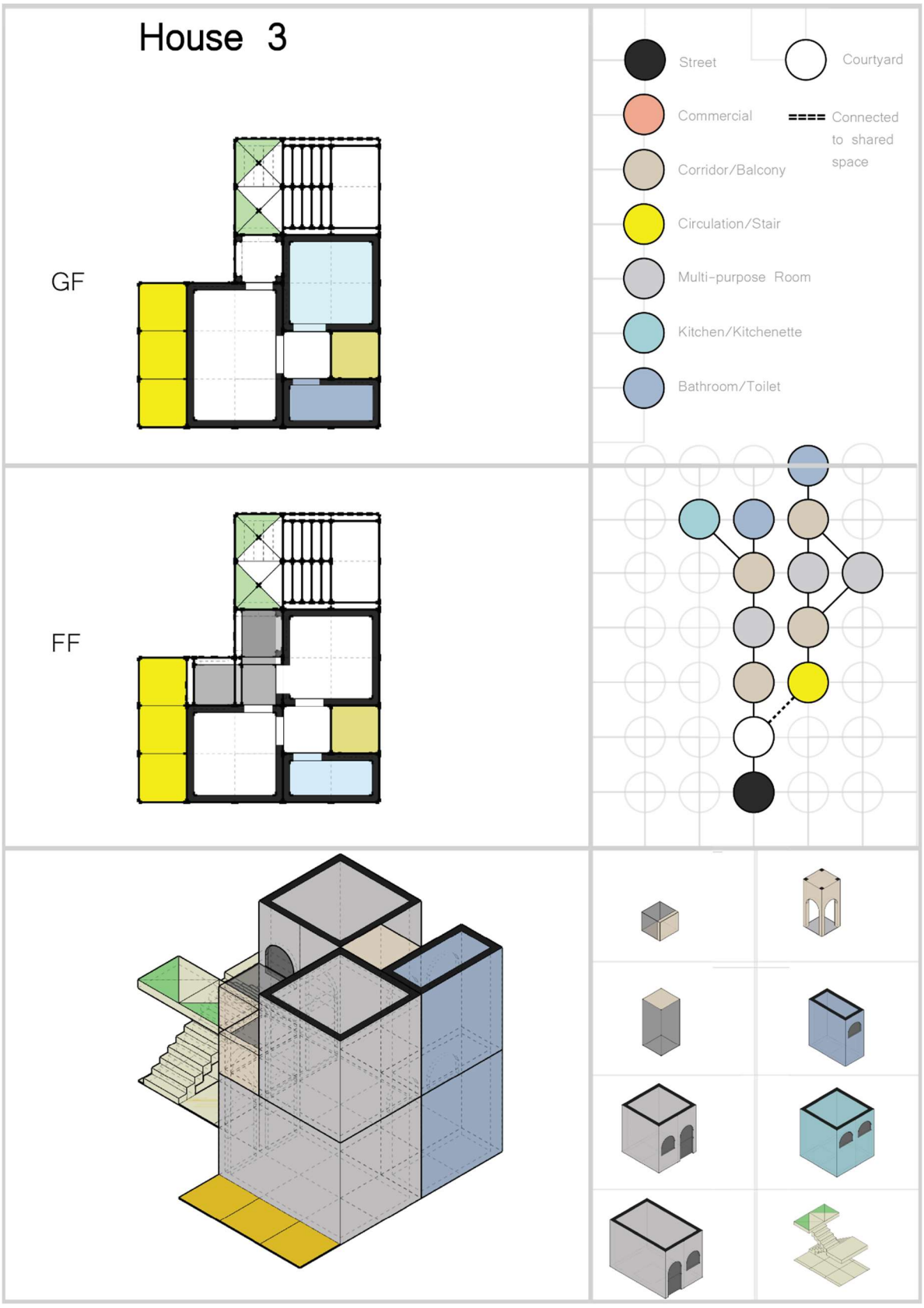


Figure 124: House 3 Configuration. By Author, 2021

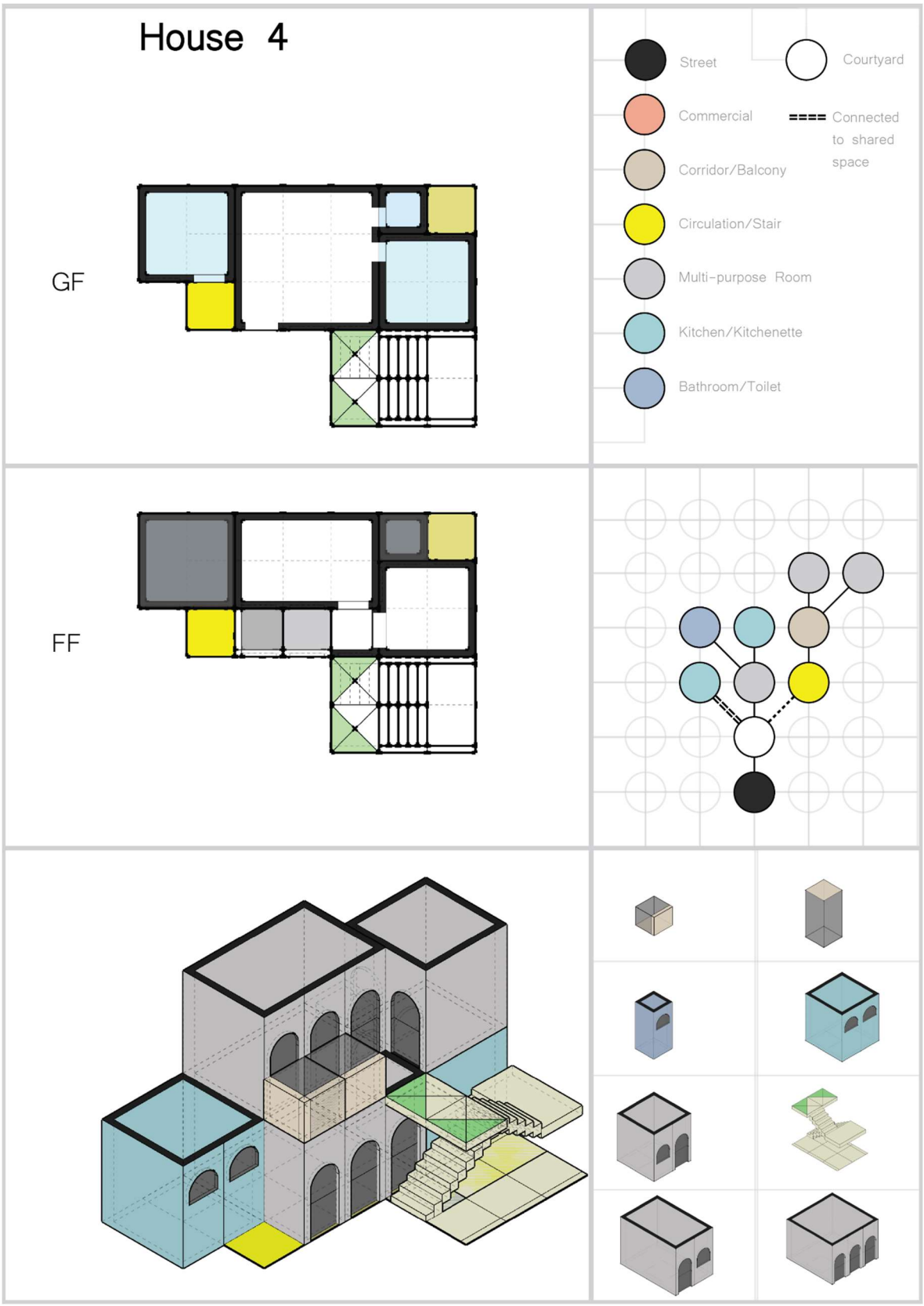


Figure 125: House 4 configuration. By Author, 2021

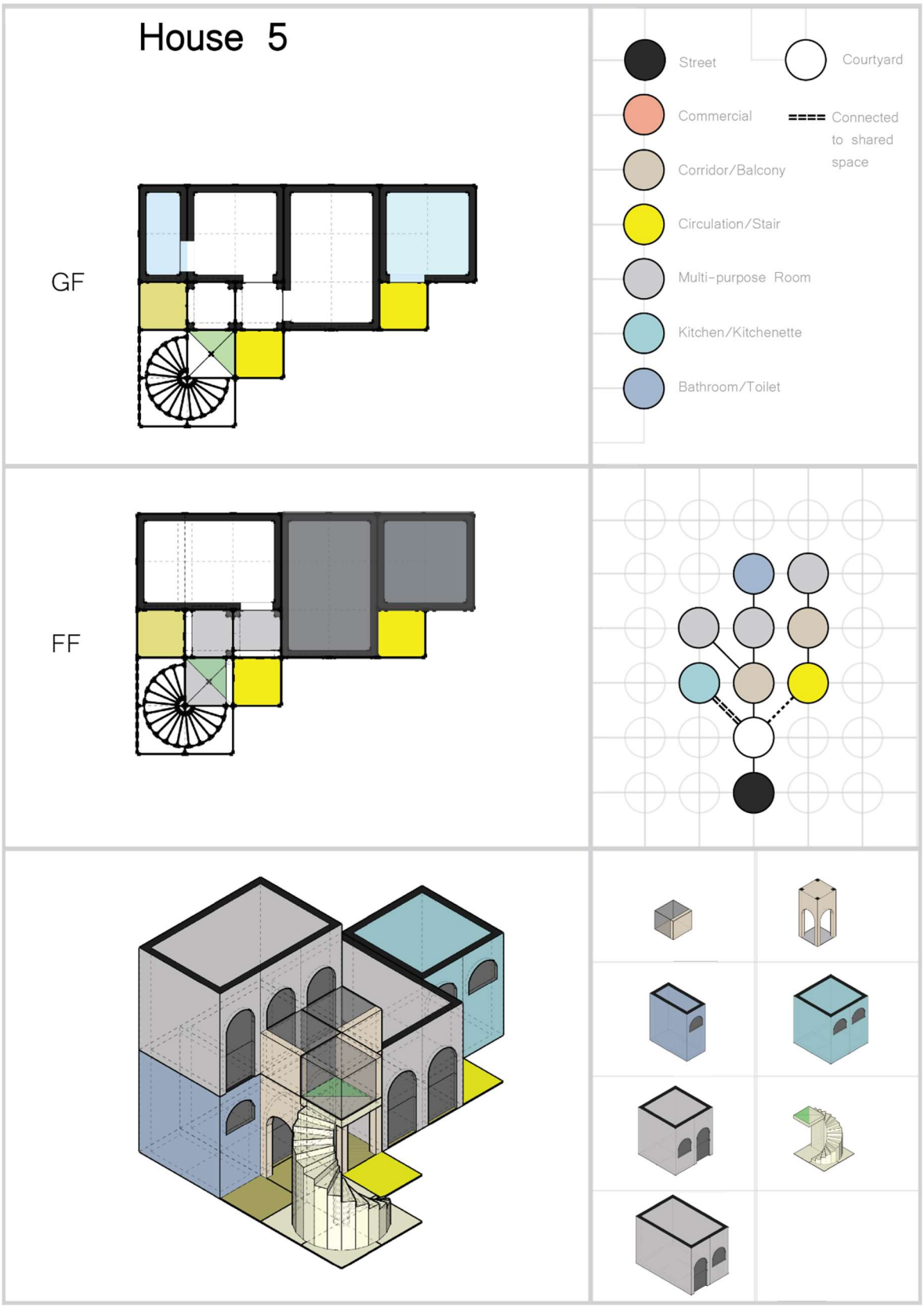


Figure 126: House 5 configuration. By Author, 2021

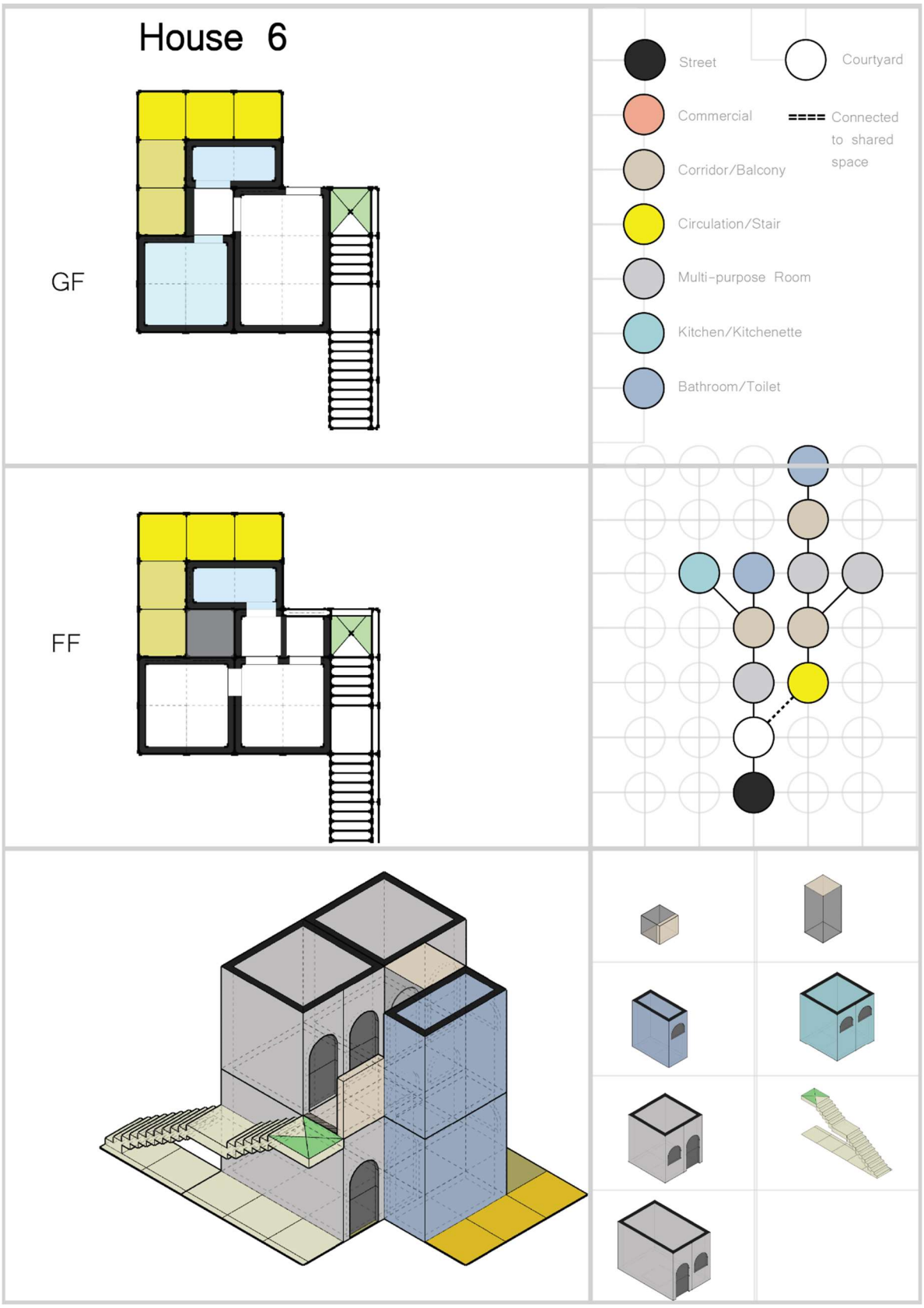


Figure 127: House 6 configuration. By Author, 2021

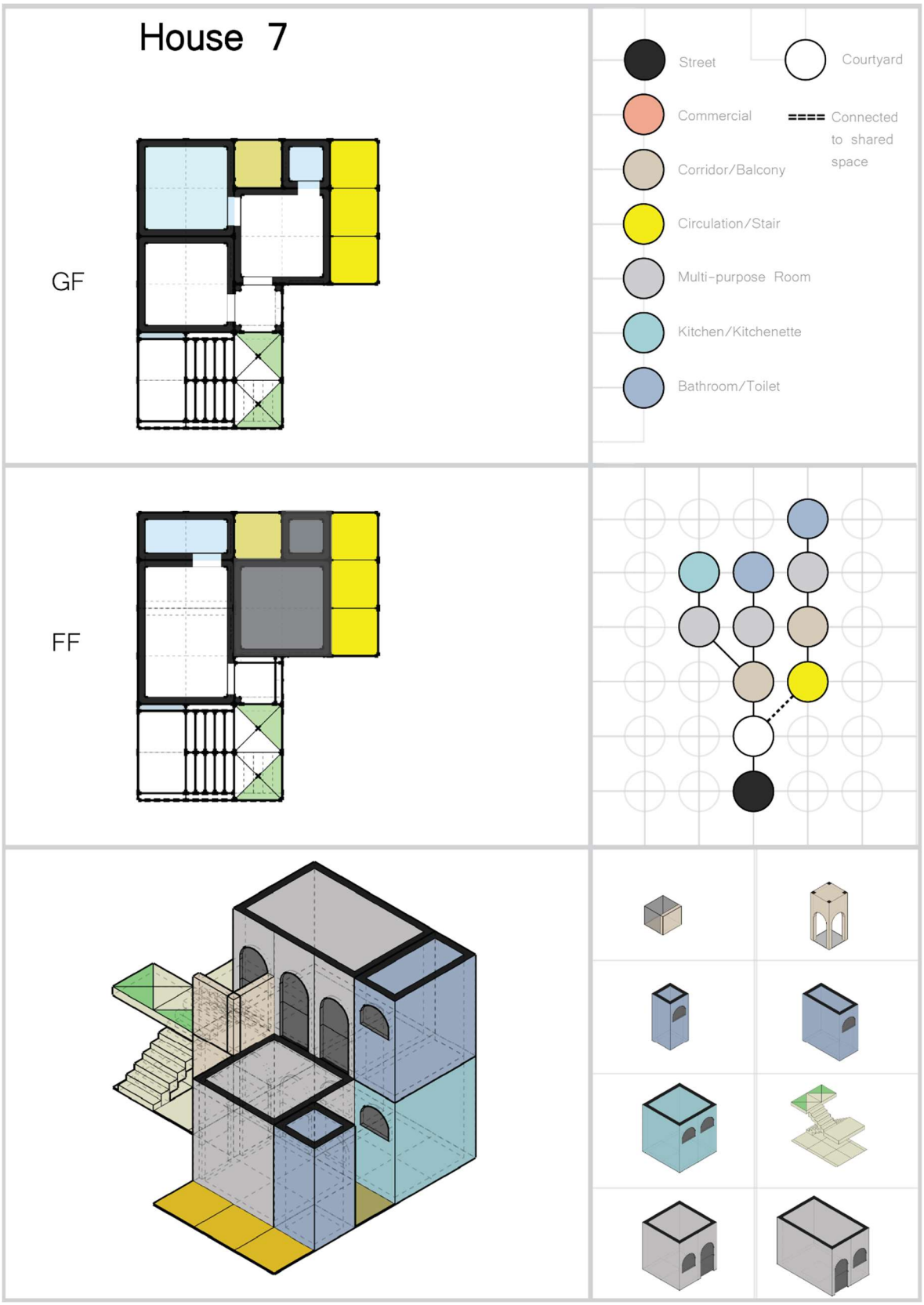


Figure 128: House 7 configuration. By Author, 2021

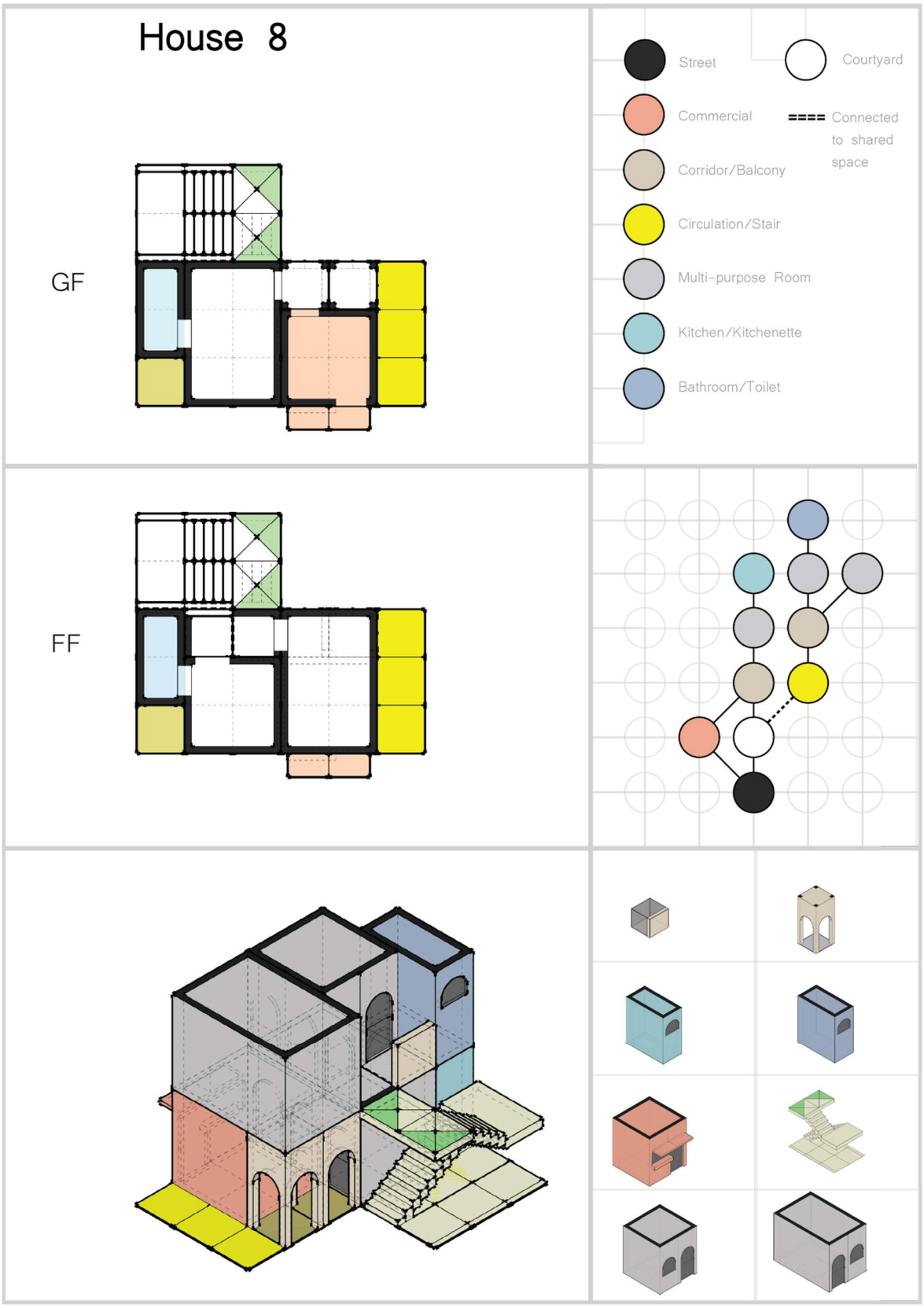


Figure 129: House 8 Configuration. By Author, 2021

5.4 LEVEL THREE FORMING & MATERIALIZATION

Figure 130: Cluster configuration. By Author, 2021

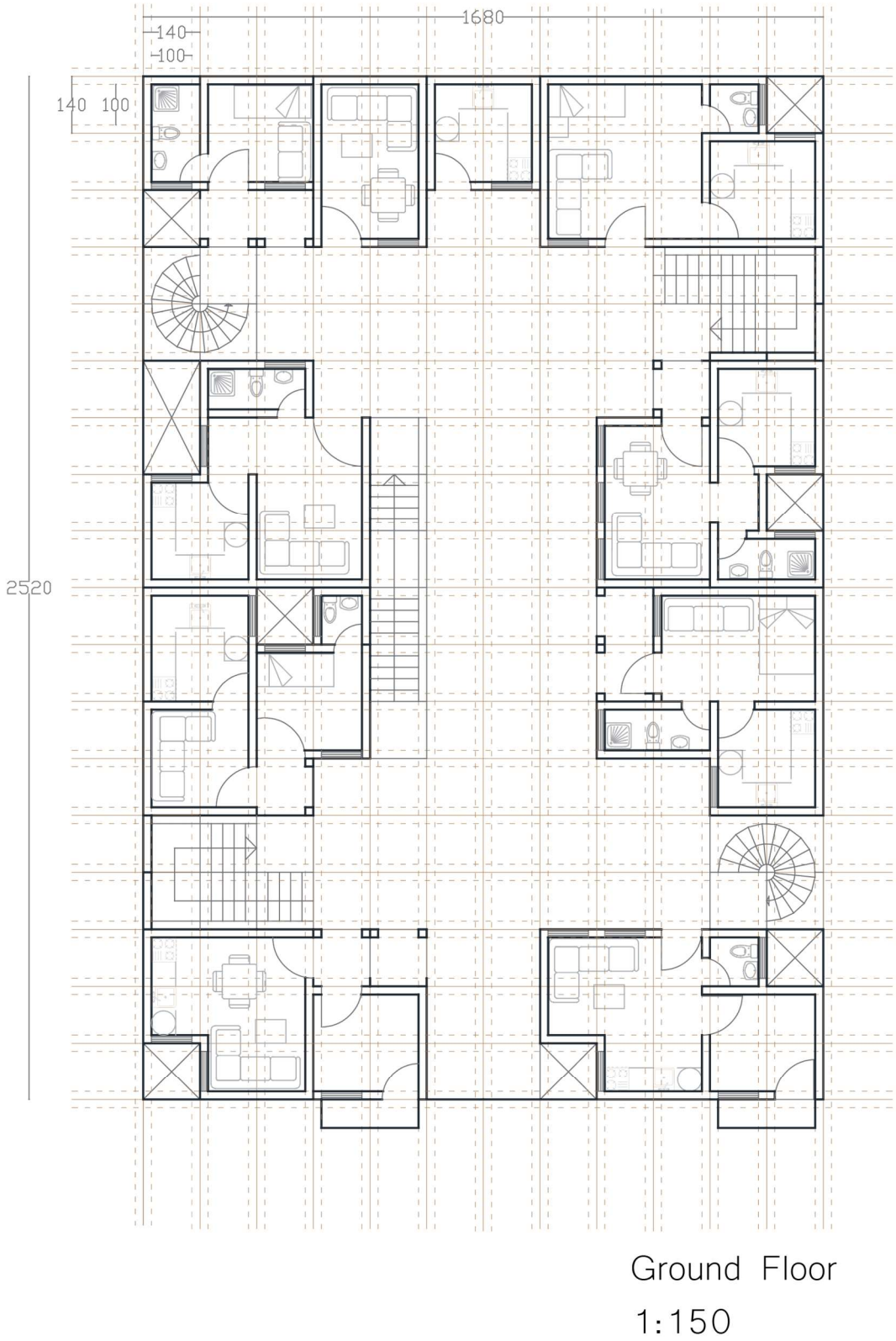


Figure 131: Ground floor plan of cluster. By Authors, 2021

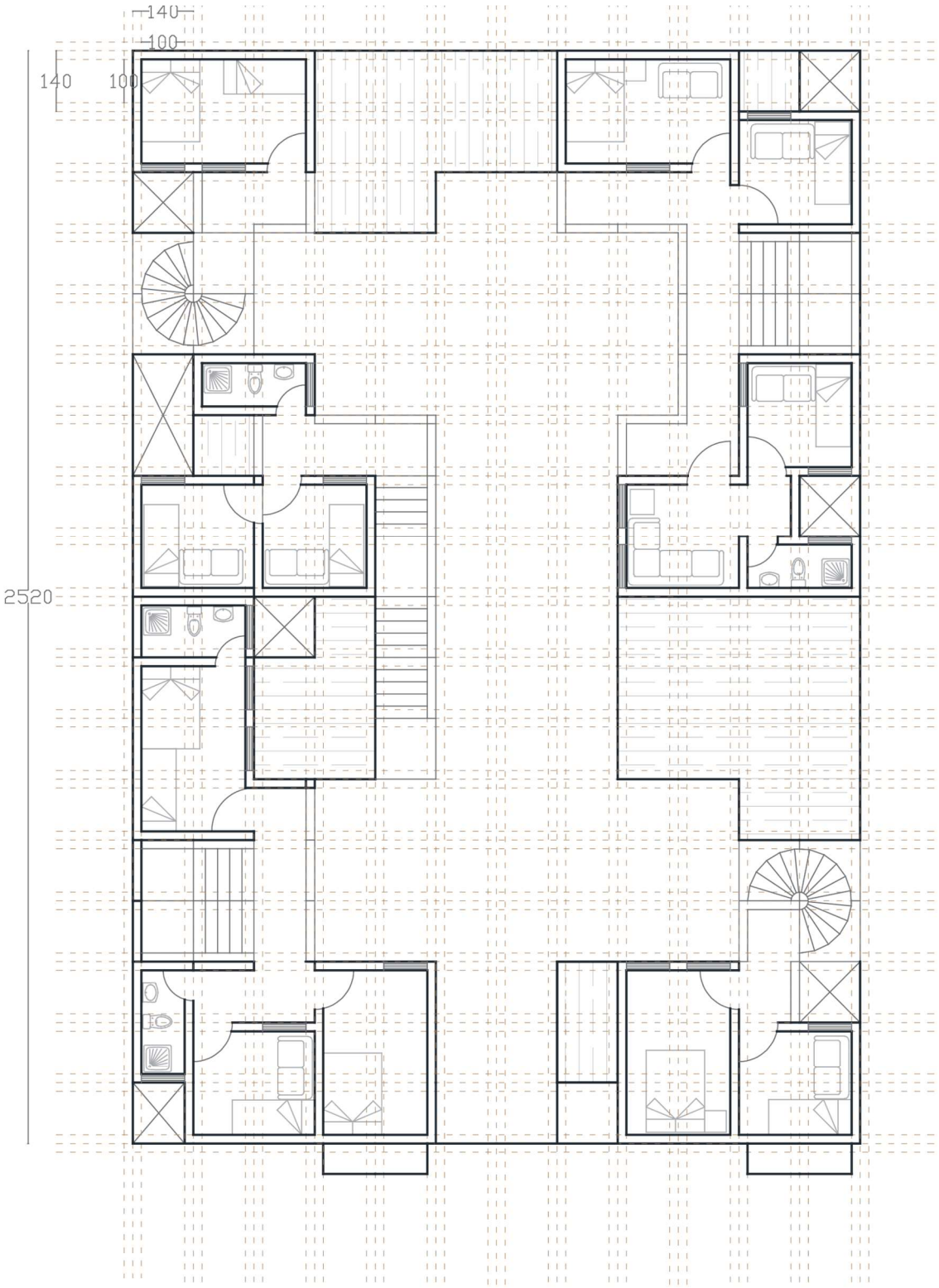


Figure 132: First floor plan. By Author, 2021

5.4.1 Re-shaping to original plot shape

The configured space can be reshaped to the original plot shape by adjusting the walls on the periphery of the configured space to align with the original plot shape. Here some adjustments to the space will need to happen, by using the graph representation of the configured space, changes can be made to arrangement of the spaces while still following the hierarchy of the configuration.

5.4.2 Demo of forming and materialization of House 5 in the cluster.

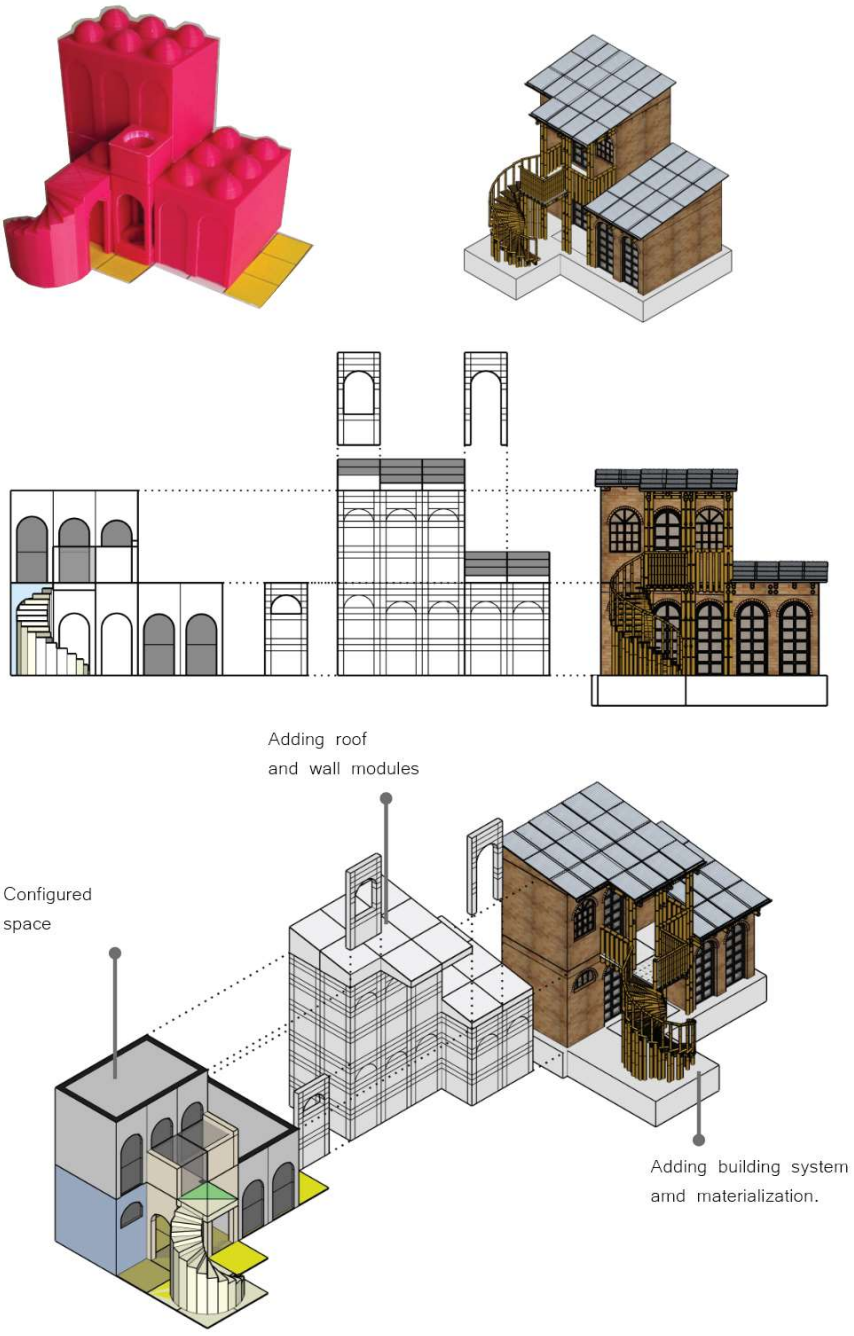


Figure 133: Transition from configured space to materialized form. By Author, 2021

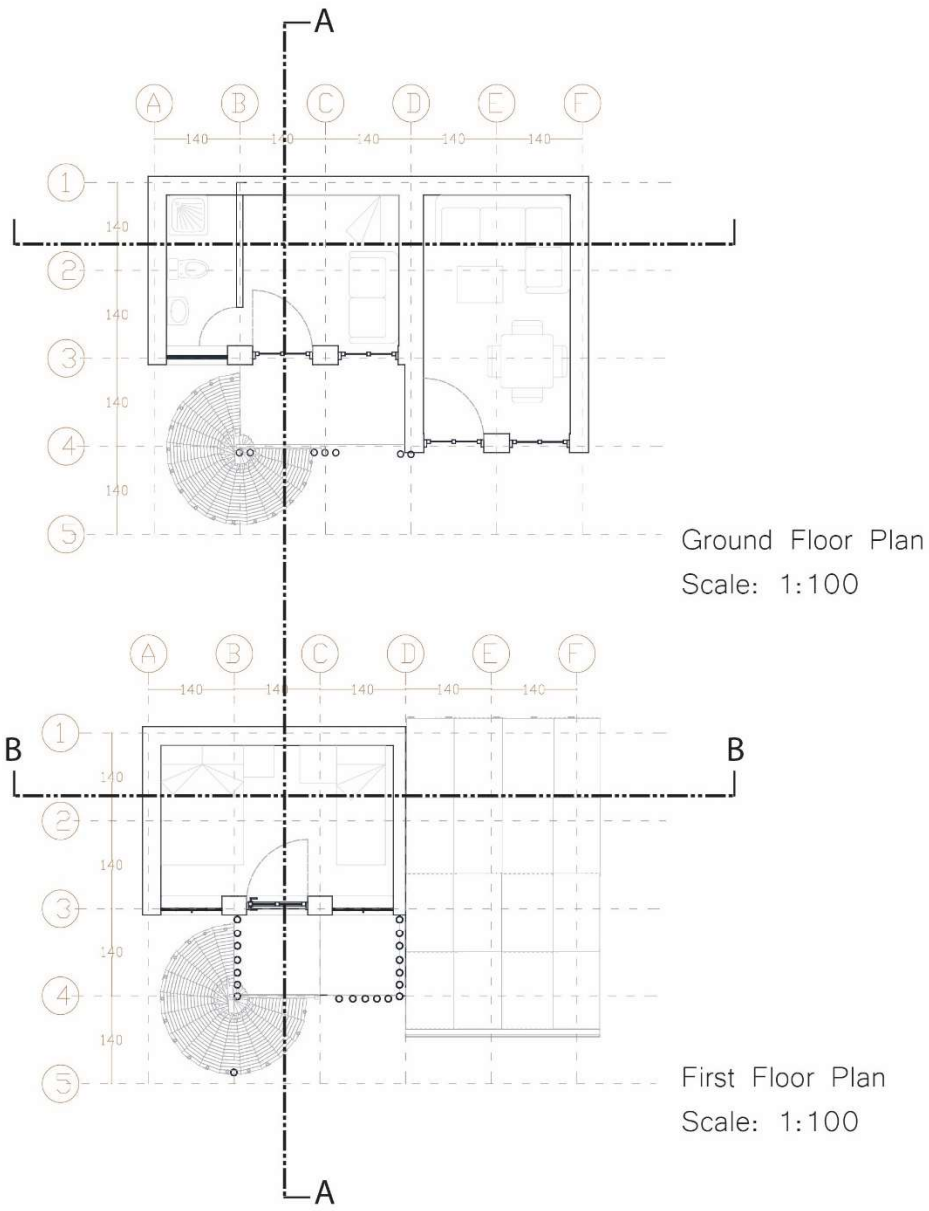
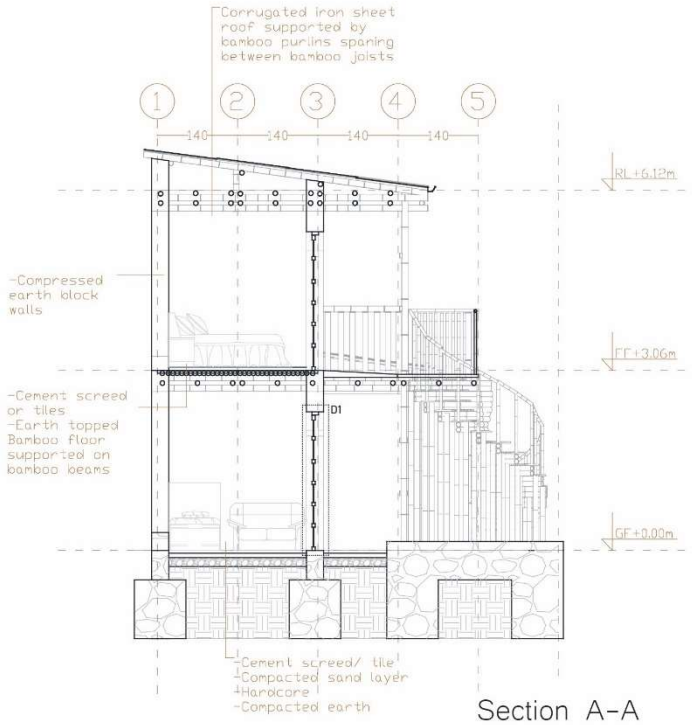
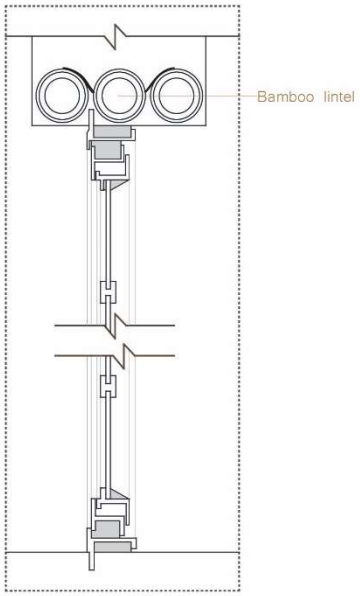


Figure 134: House 5 plans. by Author, 2021



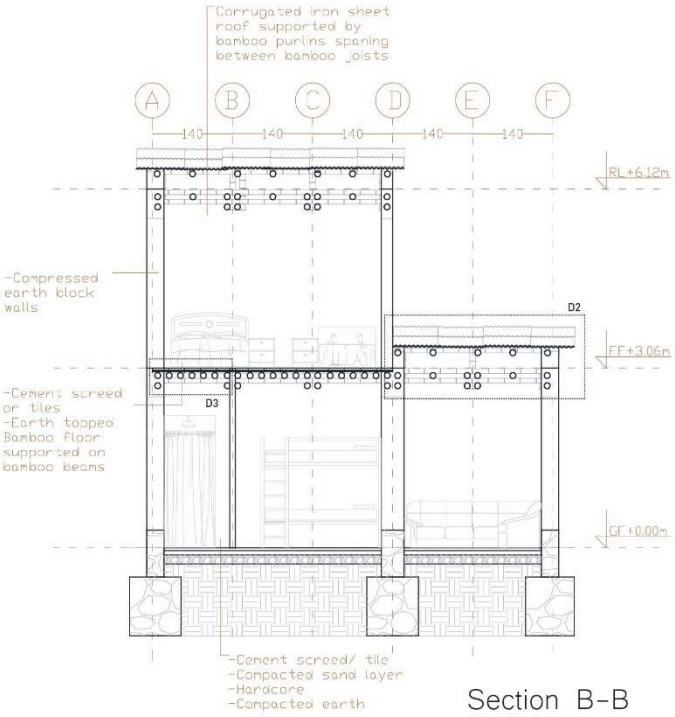
Section A-A

Scale: 1:100



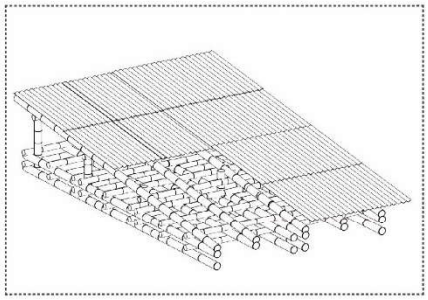
D1: Opening Detail

Scale 1:10

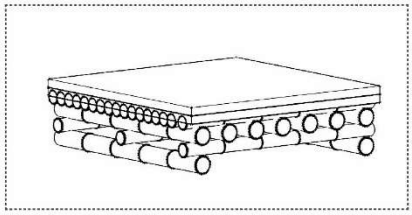


Section B-B

Scale: 1:100



D2: Roof 3D detail



D3: Floor 3D Detail

Figure 135: House 5 Sections and details.

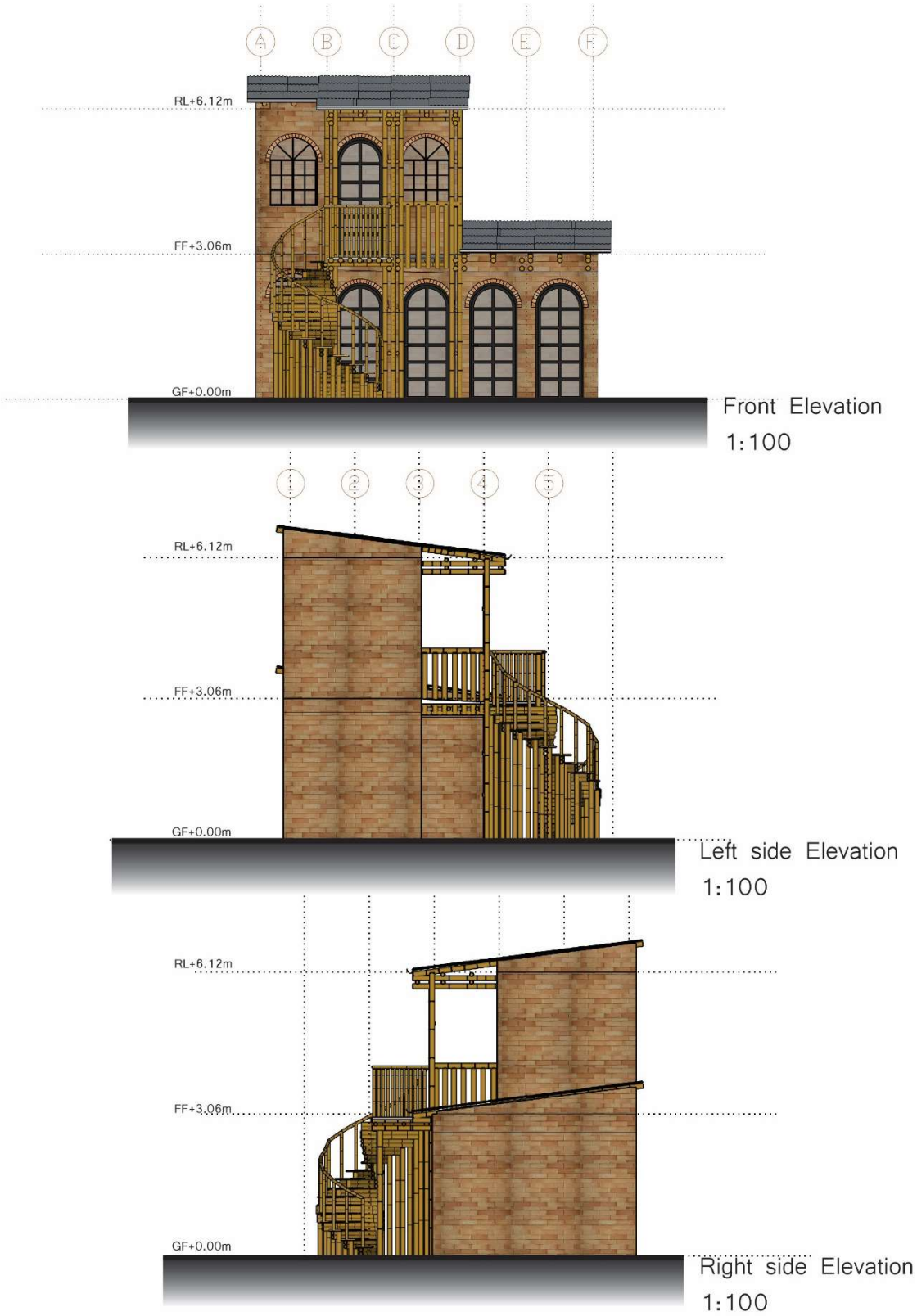


Figure 136: Elevation of House 5. By Author, 2021

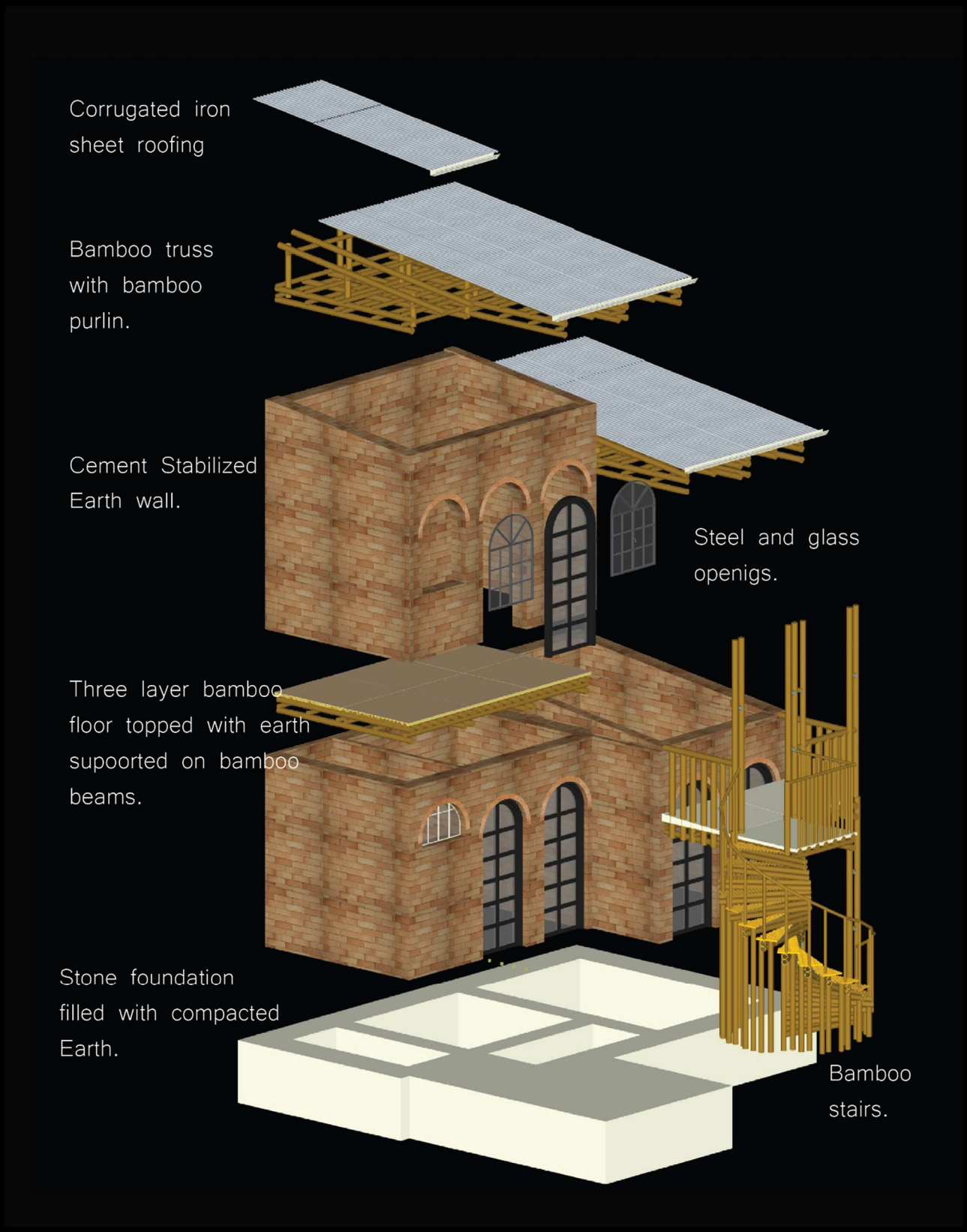


Figure 137: Exploded view. By Author 2021

5.1 GAME APPLICATIONS

5.1.1 Application for Upgrading Existing Kebele houses

The game can be used to upgrade existing Kebele compound houses. The government of Ethiopia issued a policy that kebele residents can upgrade their houses in place but they will not be compensated for their expenses in case the government decides to use the land for other development purposes in the future. Existing residents of a kebele compound can work with the Kebele administration, where they can employ the use of the participatory game to re-configure their courtyard based low-rise houses and upgrade their homes insitu. This can help the kebele house residents make use of the conditional privatization strategy proposal as stated in the Addis Ababa Structure plan (2017-2027), by meeting the minimum improvement standard required to privatize government owned property by sitting tenants.

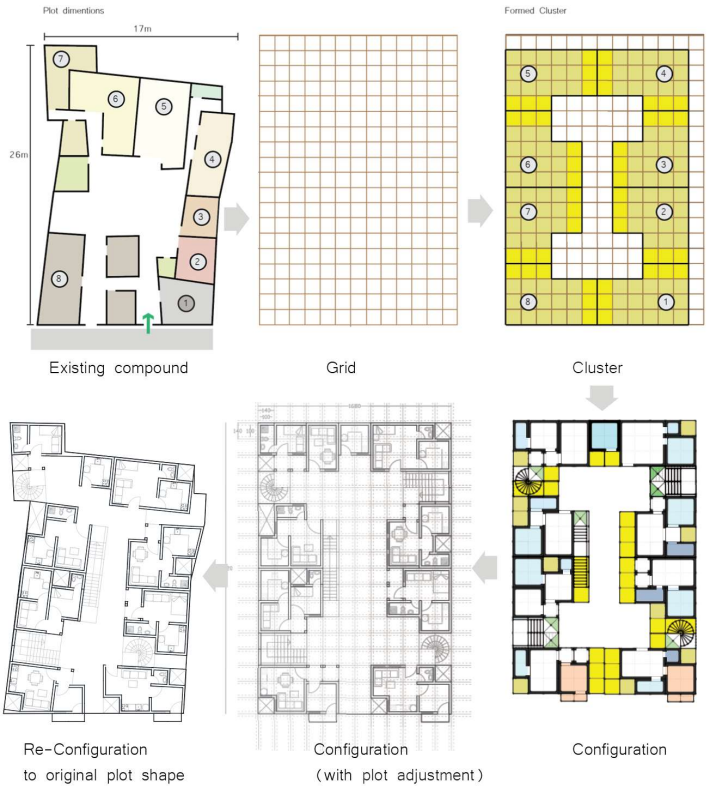


Figure 138: Application for upgrading exising Kebele houses, by Author 2021

A policy that allows kebele residents to form cooperatives and get a low-interest long-term loan to upgrade their houses will be beneficial for low-income households. In such a case, the residents of an existing kebele compound can form a cooperative where they can pool their finances and mobilize additional funding from NGOs and the government (at low-interest rates). Additionally, they can choose to employ self-help construction to further reduce cost of construction. Roles for managing finances, supervision, and maintenance can be done by members of the cooperatives on an electoral or rotating basis. The kebele administration can organize the participatory design game workshops and assign professionals to supervise the game play process or serve as game masters. The kebele administration can provide support in the provision/privatization of land, supply of subsidized building material, infrastructural services, and technical assistance.

5.1.2 Application for a new housing development proposal

The game can be used for new housing proposals in re-development projects. The end-users will be able to form clusters of homes based on their existing social network and configure their space based on their needs and priorities. The collection of these clusters then forms a neighborhood of low-rise communal housings.

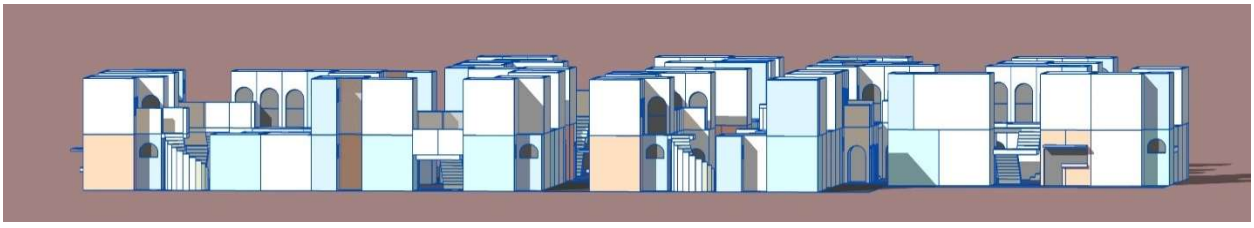


Figure 139: Neighborhood configuration. By Author, 2021

One way of approaching this is to form a housing scheme similar to 20/80 or 40/60 condominium but instead of registering individuals, the end-users can form cooperatives by grouping (4,6,8,10,12) households. In this way, each cooperative will belong to one cluster of low-rise courtyard-based housing. The collection of such clusters will then form the low-rise neighborhood.

The game can be further expanded at the tissue level by addition of clustering rules and integration of infrastructure and required facilities.

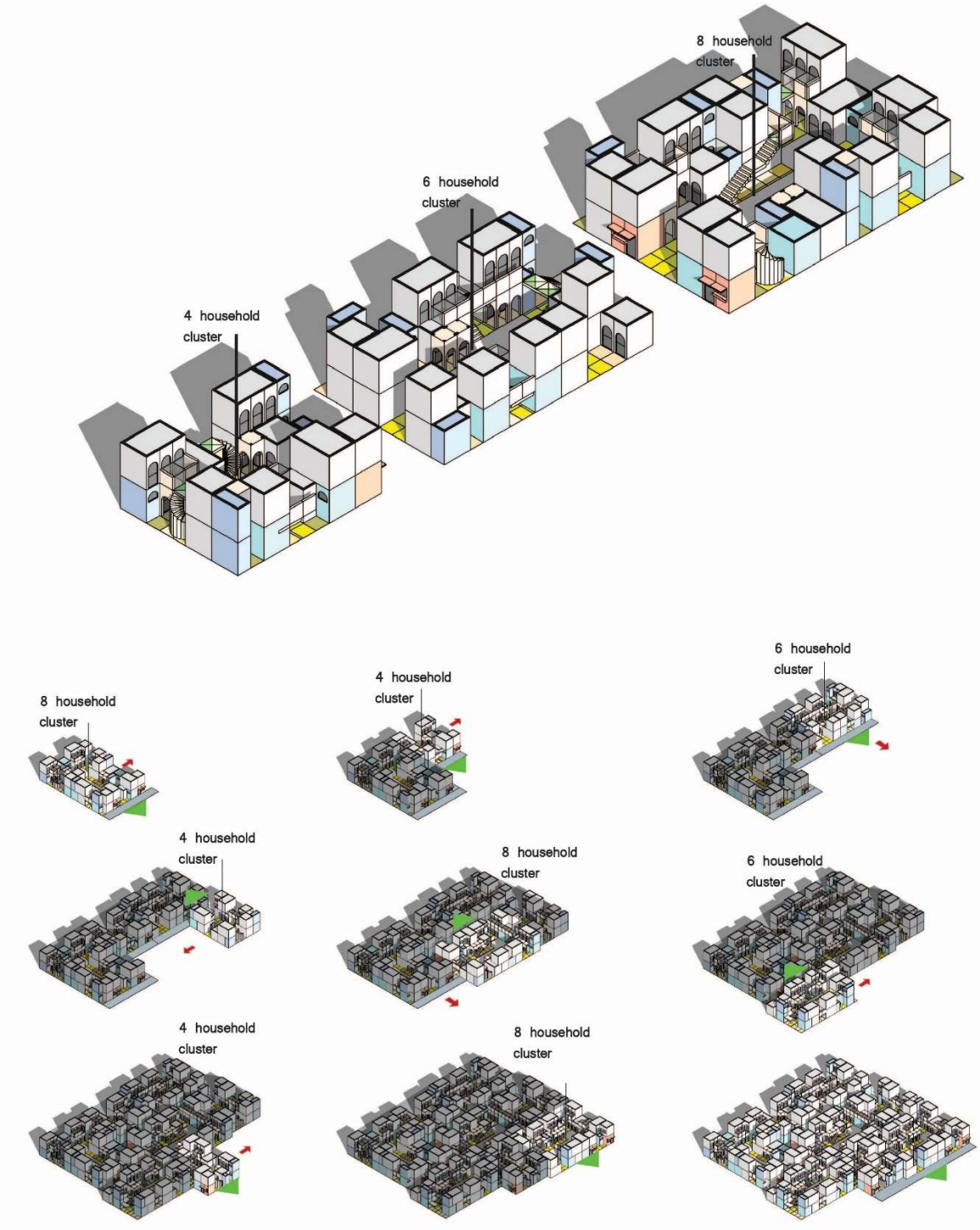


Figure 140: Applicaton for New Development. By Author, 2021

5.1.3 Application for new-configuration

The game can alternatively be used to gauge the end-users' spatial needs and their preference of hierarchal arrangement of spaces that can inform the development of new housing typologies that are more personalized to the end-user's need.

The end-users configure their space using the game, the graph representation of the configuration can be extracted and used to understand the preferred/ required spatial hierarchy. This can be used to generate layouts that follow the desired configuration.

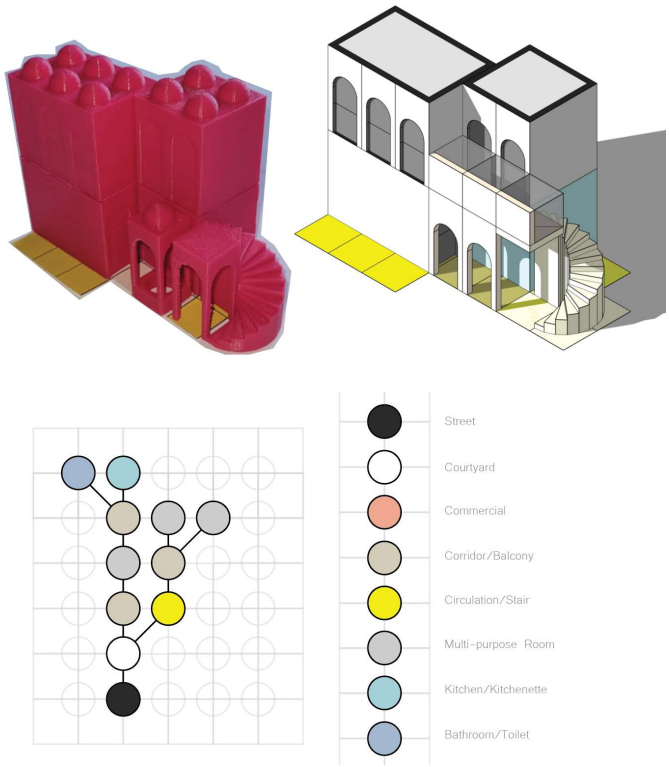


Figure 141: Application for Configuration. By Author, 2021

5.1.4 Analyzing user needs

The game can be used to identify spatial priorities of end-users. The use of tokens creates a trade-off requiring users to weigh between different domestic spaces and functions to identify their immediate spatial needs. During the play session, game modules are volumetric representations of space which are placed on the board depicting the plot or space budget allocated for each household. Each module comes at a price, the players are allocated a budget in form of tokens, this forces users to compare spaces in terms of size and function and reach at a decision based on trade-offs and compromises. The game can be also used to identify which spaces users are willing to share and which activities can take place in the shared space.

5.1.5 Density comparison between IHDP condominiums and proposed new low-rise incremental housing

According to the Addis Ababa structural plan, the housing density should be 150hu/ha the CBD, 100hu/ha in the inner city and 50hu/ha in expansion areas. IHDP projects range in density from 175 to 300 units per hectare. The condominium blocks are mainly G+4 and G+5 building blocks with the newer constructions having 7 floors and above. There are 4 basic typologies in each condominium block: a studio, 1-bedroom, 2-bedroom, and 3-bedroom unit types.

Typology	Percentage per block
Studio	20%
1 Bedroom	40%
2 Bedroom	20%
3 Bedroom	20%

Table 8: Typology and percentage per block.

Sixty percent of the housing units in one block is composed of 1 bedroom and studio units because that is more affordable in comparison. This is not ideal for low-income residents with average household size of 4-6 people.

The proposed low-rise incremental housing has a density that ranges from 182 to 204 units per hectare. It allows for horizontal and vertical incremental growth as required by each household as the financial capacity of the household improves or with an increase in family size.

Cluster size	Number of Units	Area in m2	Unit/ hectare
4 household cluster	4	196	204
6 household cluster	6	313.6	191
8 household cluster	8	420	185
10 household cluster	10	548.8	182
12 household cluster	12	713.4	196

Table 9: Density of low-rise incremental housing.

The low-rise incremental proposal has a higher minimum density in comparision to the condominiums, Eventhough the maximum density achieved by the condominiums is higher than the low-rise, 60% of the condominium stock is either a studio or a one bedroom with 20-30m2 of space, which doesn't accomodiate the large household sizes of low-income residents. Wherein the incremental development, the households have a space budget close to 50m2 which can be doubled by adding another floor. Therefore the space will be able to house more people compared to condominium units.

CHAPTER VI

6 CHAPTER 6- CONCLUSION

This research started with an ambition to develop a gamified design methodology that allows end-users to make design decisions. The motivation for developing a participatory design game stems from the context of Addis Ababa slums and the lack of slum renewal programs that allow low-income residents participate in the renewal design decision making process in a meaningful way. The major problems of slum renewal projects in Addis Ababa are the loss of locational advantage, loss of inherent socio-economic network, loss of home-based income generating activities (usually location and courtyard dependent), affordability, and housing typology proposals that don't meet the needs of low-income households. Based on the contextual study of patterns of habitation and social networks in kebele compound houses and studies of affordable housing solutions for low-income residents across the world; the research was geared towards creating a design game for users to generate a low-rise courtyard-based incremental housing configuration through the play process. The reason behind this is that residents of kebele houses rely on the courtyard space to carry out activities (domestic and commercial) and use it as an extension to their homes. The dwellers are co-dependent on their social network; there is a strong sense of community and mutual support. By allowing users to configure their own dwelling space, the user's need and priorities can be reflected in the design which otherwise may not be so in the typical top-down conventional design method. The main research question of the study is, how can end-users co-create valid designs using pre-defined modules, simple configuration guides/rules, and a sequence of stakeholder inputs? The research question led to the development of a design game that abstracts the working spatial and social qualities of the kebele houses and embedding them into a system of configurational elements and rules. The research then posed the design question; How should the pre-defined modules be designed with respect to existing/required proportion and scale of programmatic functions? This is done by first creating a modular coordination system using a double band tartan grid. The tartan grid was dimensioned so the minimum internal space is 1m with 20cm band on either side allowing the use of different building systems. The type and size of the modules were defined based on the studied patterns of habitation, and domestic & commercial activities. As the game allows users to generate courtyard based communal dwellings, a system of creating clusters with a central courtyard was proposed using boards. These boards are essentially the space budget of a household. The size of the board was referenced from the Addis Ababa structural plan proposal of allocating 50m2/ household for special (site and services/ incremental) housing. Based on these, 3 different types of boards are defined along with rules on how these boards can be combined to form clusters of various sizes. The research further explores the design by questioning, How should the incremental configuration guides/rules be developed? Simple configurational rules were defined to guide users/players on how the modules representing functional volumetric spaces can be configured on the board. These rules are kept simple to give more flexibility for the users/players to generate a variety of configurations. The configuration rules include a validity check that ensures the user/player configured spaces are valid and are in accord with the configuration rules. And finally, the research examines, How the stakeholders should take part in the design decision-making process? The introduction of tokens to acquire modules creates a trade-off where users/players have to prioritize their immediate spatial needs and also make decisions on shared spaces with shared costs. The introduction of activity cards for the shared compound space adds another level of collective decision making and negotiation. The game operates on three levels, the cluster level, the configuration level and the forming and materialization level. In the play process, the architect/ gamemaster acts as a facilitator of the game play. Once the players are happy with their configurations, the next step is to adjust the building elements. Here the players can choose the building system, wall type, opening type, roof type, and architectural style of the configured space. The research only shows a demo of one test case, but various types of architectural styles, building systems and construction materials can be used.

6.1 DISCUSSION

There were three main driving factors for the research. The first is participation, the second is the gamified approach and the third is the context. In the start of the research, it was essential to define the type and level of participation desired to be achieved. The project aimed for the highest level of participation that allows for citizen control/ genuine participation. The game approach needed to simply the configuration process allowing nonprofessionals to easily interact and configure their space. For this reason, a visual and tangible game with physical props was defined. Study of the context and case studies led to the definition of the game to be designed for use in the development of a low-rise courtyard based communal housing. The game elements and the modular coordination system were defined based on the contextual study and literature review. It was essential to define simple game rules both for the game play process and the definition of new game elements. The point of difference for the research is that the development of the game is documented showing the derivation of game elements from the context. The game was initially though for upgrading existing kebele compounds on site, but in the process of the game development the potential of using the game for proposing new housing re-developments projects was evident. The game can be used to engage end-users in the planning and design process for affordable housing proposals that use low-rise and incremental development as a strategy. Further applications of the game include the generation of new typologies and layouts based on the graph representations derived from the game play configuration output. In addition, the game can be valuable to understand and analyze end-user needs and priorities by facilitating trade-offs as well as to form a consensus on communal/shared spaces.

6.2 LIMITATIONS

This research mainly focuses on the configurational and participation aspect of affordable housing and may be lacking in other facets of the subject. The project narrowed down to focus on the participation of end-users at the housing scale to minimize the scope and the broad range of stakeholders involved at larger scales. While there is indeed many resources regarding using serious games for ideating solutions and reaching consensus at an urban scale; The lack of extensive and relevant literature on use of design games and board games for proposing designs at a housing level made the process of the project challenging. The game was not extensively tested and evaluated as it requires the physical presence of players which doesn't align with the current corona virus safety measures. While brief policy and financing suggestions have been presented in the research, the application of the game in urban renewal and redevelopment projects requires further research at a larger scale to include policy changes and financing schemes.

7 APPENDIX

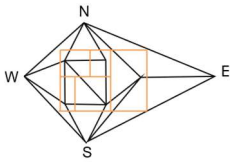
7.1 GAME RESOURCES

The game elements can be accessed from the following public git repository : https://github.com/bezawitzyb/Thesis_BZB . The modules can be downloaded and 3D printed for holding a game play session.

7.2 REFLECTION

• Aspect 1 the relationship between research and design.

The project aims at creating a participatory design game that can be used for upgrading slum areas within Addis Ababa. The design development of the participatory design game is informed by the two-part research conducted; the first part of the research discusses theories about participation in architectural design. This part of the research discusses the importance and level of participation. Here, theories about participatory methods that allow communities to exercise control of the design decision making process are discussed. The use of serious games as a collaborative design tool that enables non-professionals to actively take part in the design process is explored through creation of a rule-based system encompassing open building principles involving standardized/modular parts that can be configured in multiple ways. The architect in this case is engaged as a facilitator/ game master.



Second part of the research is focused on understanding the context of Addis Ababa. This part of the research explores the socio-economic fabric of characteristically slum neighborhoods of Addis Ababa. A large stock of slum houses is government owned, commonly referred to as kebele houses, and administered by the kebele (kebele is the lowest tier of the city administration established to subdivide and restructure the city). The research explores patterns of habitation through literature review and field study to understand the domestic and small-scale commercial use of space, socio-economic interdependence, locational advantage and the living environment of the community residing in kebele compound houses. The existing slum redevelopment strategy and affordable housing policy is briefly described and the system of allocation and cost is presented. Based on literature review, it is identified that the affordable housing programs employed within and around Addis Ababa often involve relocation causing loss of locational advantage and socio-economic ties. The affordable housing programs are often do not fall within budget for low-income households and in most cases, the allotted space and spatial configuration does not respect priority of the slum dwellers in relation to their life-style, socio-economic and environmental conditions. Based on this, the proposed slum upgrading strategy is to allow slum dwellers to incrementally improve their housing conditions as their financial situation improves and/or as the needs of the households change over time. This part of the research further examines case studies for incremental housing programs. Based on the contextual study a design brief is established to develop a design game.

The design brief is to create a tangible and visual method for eliciting the shareholder's spatial needs using a game-based approach. The design game resembles a board game in conjunction with Lego and functions on more abstract level in relation to the built environment. The design game is intended for use in collaborative design that allows end users to configure their space based on their spatial requirements and priorities which otherwise may not be met by standard conventional design in the top-down approach. The game will essentially abstract and simplify low-rise courtyard-based incremental housing design into a system of simple configurational rules and design elements that allows the stakeholders to easily engage in the design process. This system of design flows a modular co-ordination system based upon a tartan grid. The end users use the game elements (boards, modules, activity cards & tokens) to configure their space based on the defined game rules. In the game play process, the stakeholders (players) will identify and weigh different domestic and commercial spaces, functions and sizes based upon their priority to form their configuration of hierarchic spatial framework and shared spaces. The game will serve as a simulation of a design problem that facilitates trade-offs, design ideation, projection of stakeholder needs and preferences, and co-creation.

- **Aspect 2 the relationship between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS).**

The studio topic of my graduation project is gamification of generative design where the focus in my case is participatory architecture. My graduation project aims to create a design game that allows non-professionals to configure their space based on their needs and priorities following a set of simple rules. The context of the project is slums of Addis Ababa and the project specifically focuses on upgrading kebele compound houses. The project aims to marry design and participation through a rule-based game; hence, the topic intersects between architectural design, (user)generative design and game design. In this sense it is a multi-disciplinary study that encompasses different aspects of the Master's program.

- **Aspect 3 Elaboration on research method and approach chosen by the student in relation to the graduation studio methodical line of inquiry, reflecting thereby upon the scientific relevance of the work.**

The research methodology is conducted as research by design, where a theoretical framework is developed through literature review that informs the design and development, followed by testing the developed game and evaluating the results.

1. Literature review

   The literature review is divided into two parts, the first part discusses theories about serious games as participatory design tools and explores studies of its application in collaborative design. Here collaborative design is explored and theories about how rule-based systems can be developed based on the studies of spatial morphology using modular systems and incorporating open building concept are discussed. Understanding of the type and level of participation, game mechanics, game components and rule-based configuration systems inform the design development stage of the research.

   The second part of the literature review discusses the case, where the context of Addis Ababa's slum neighborhoods is defined. Patterns of habitation, spatial morphology and socio-economic construct of Kebele housing compounds are studied. Furthermore, the existing slum redevelopment strategy and affordable housing policy is briefly described and the system of allocation, cost, and spatial study is presented. Here an alternative method of upgrading kebele houses is proposed involving courtyard based incremental development that accommodates the existing density of the kebele houses. The

study of the case is used to define the design brief and inform the design development of the game components.

2. Design Development

Following the design brief of developing a design game that can be used by non-professionals to re-configure and upgrade their kebele dwelling units, the design game components are defined. Here the modules, modular units and configuration rules are defined based on the studied patterns of habitation, spatial morphology and principles of open building concept. The design game is planned in 3 stages. As mentioned earlier, the design game is used for generating collective design for low-rise courtyard based communal housings. The first stage of the game is to layout the clustering of the houses in a way that the courtyard is central. This stage of the game is the cluster level. To do this, boards representing plots are designed, these boards can be connected in a number of ways continuously to form a chain like cluster with a central courtyard. The second level of the game is the configuration level. Here the players (stakeholders) can configure their houses and shared spaces using a set of predefined modules according to their needs and preference. The players use their tokens to acquire modules. To compensate for the limited space (module acquired), the player can choose to use the shared courtyard space as an extension to their home activities by indicating it using the activity cards. The third level of the game is formation level. Following the chosen building system and material, the players can select the wall, opening and roof type of their configured space. Here, other modifications may take place, such as determining wall thickness based on structural requirements, and functional use (load bearing or partition walls).

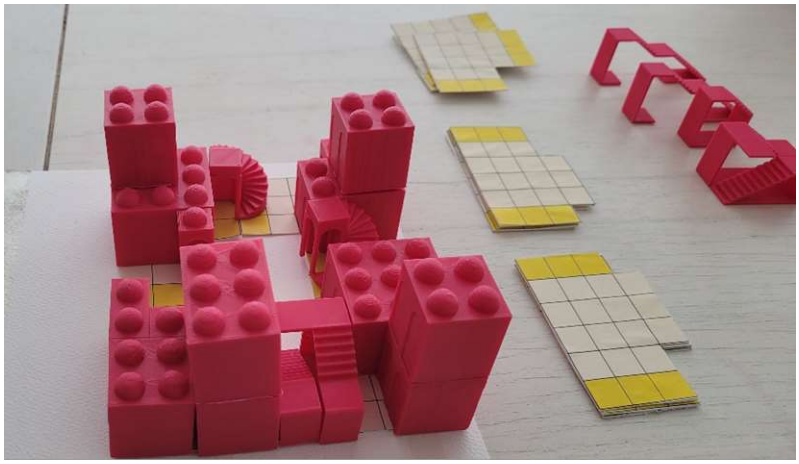


Figure 142: Spatial configuration of a 4-household courtyard housing cluster.

3. Testing, Documenting and Evaluation

The developed design game is initially tested digitally by to determine simplicity of the configuration rules and test whether it allows for multiple configurations. After the digital testing and modification, the game components are 3D printed accompanied by a game rulebook that will be further tested by playing the game. Here the play process and output are documented. A demo of the game play process and output will be presented. The formed configurations are checked for validity. After which the results will be discussed and recommendations will be posed for further study.

- **Aspect 4 Elaboration on the relationship between the graduation project and the wider social, professional and scientific framework, touching upon the transferability of the project results.**

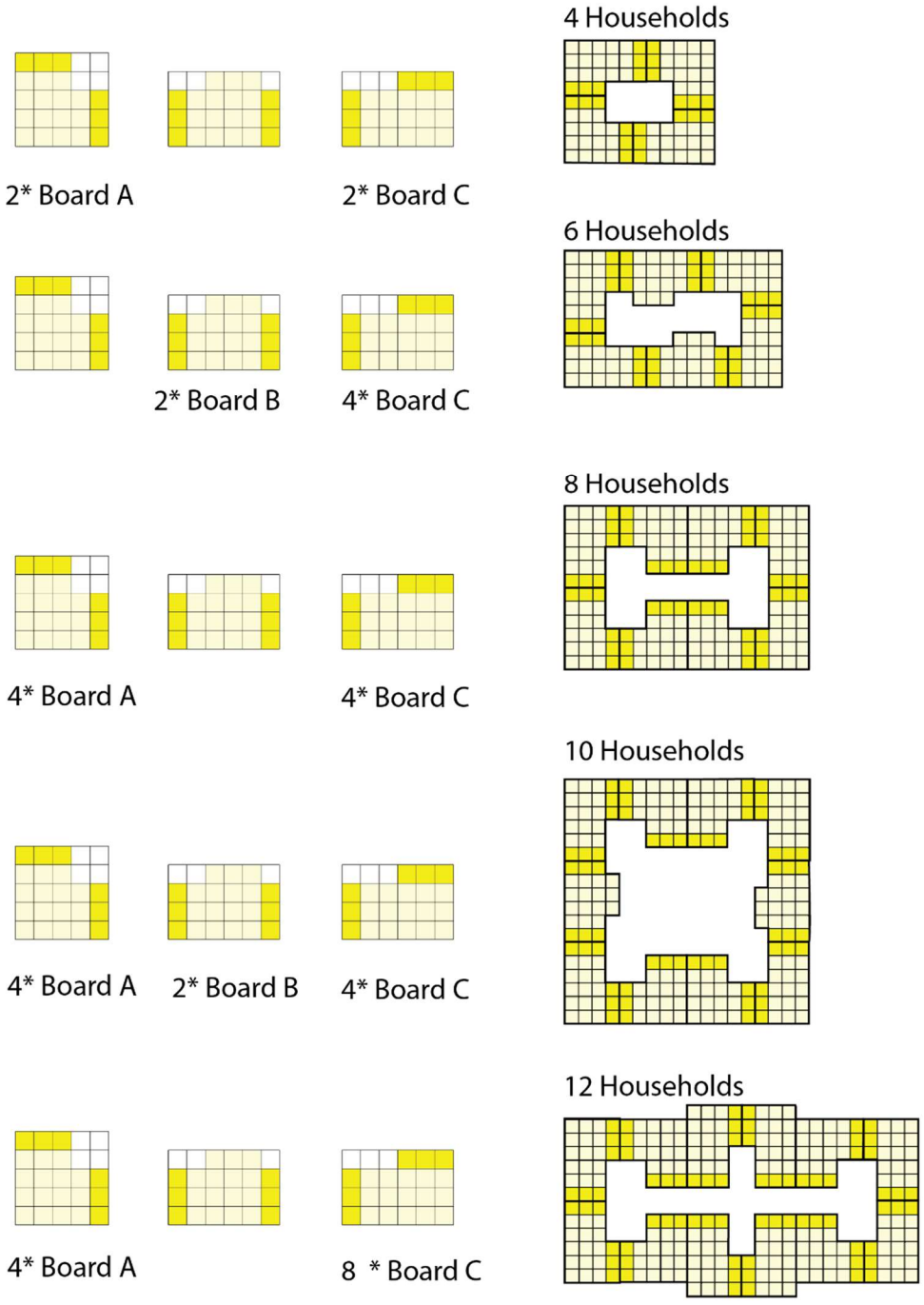
The social relevance of the research is to find a way where end users (low-income communities) can be directly involved in the design decision making of their environment. Many characteristically slum neighborhoods serve a multi-use, where domestic production and small-scale commerce takes place. Therefore, the livelihood and self-sustenance of these communities depend on the socio-economic structure, multifunctionality and locational advantage of these spaces. These socio-economic and spatial values should be considered in renewal and redevelopment strategies by a means of participatory design. The aim of the research is to develop a participatory design methodology where the end users are protagonists in the design decision making where the spatial values inherent to the existing community can be preserved or perhaps enhanced. By developing a configurative game that uses a simple set of rules, non-professionals will be able to re-configure their space in an incremental manner that is somewhat structured by the simple game rules. The scientific relevance of the research is the development of a participatory design methodology using game mechanics that aims to abstract and embed existing working spatial values and social complexities with the use of grammatic rules derived from scientific methods like graph theory and game design theories.

- **Aspect 5 Discuss the ethical issues and dilemmas you may have encountered in (i) doing the research, (ii, if applicable) elaborating the design and (iii) potential applications of the results in practice.**

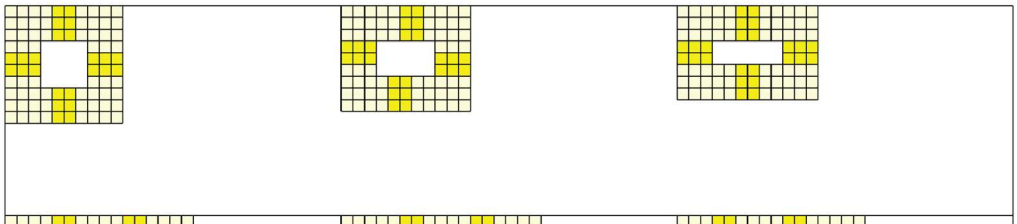
Affordable housing is a very challenging subject to tackle, there are many aspects that need to be considered to propose a viable solution. Matters of land, tenure, cost, population growth, available building materials, city development plans are some factors taken into consideration when proposing housing solutions but matters of locational advantage, patterns of habitation, means of livelihood, priorities of spatial configuration, growth of household and incremental development are aspects that are equally important and should be considered when thinking about proposing housing solutions for low-income dwellers. Doing so will require extensive research and derivation of new housing policies. While my research focuses on participatory architecture, it may fall short on considering all the different aspects of affordable housing. The game I developed is a cross between a board game and Lego, it requires physical presence and interaction of stakeholders. For this reason, the game was not tested thoroughly because of set corona virus safety measures. Through the research, I explored a methodology of design that utilizes game mechanics where by the use of a set of modules and a rule-based system, the dwellers can generate designs that respect their spatial values, patterns of habitation and allow them to think and design incrementally. Potential application of the game is to engage end-users in the design process of slum upgrading projects that use incremental housing as a strategy and as a design method to develop a new user-centric incremental housing proposals for low-income communities.

7.3 CLUSTER CATALOGUE

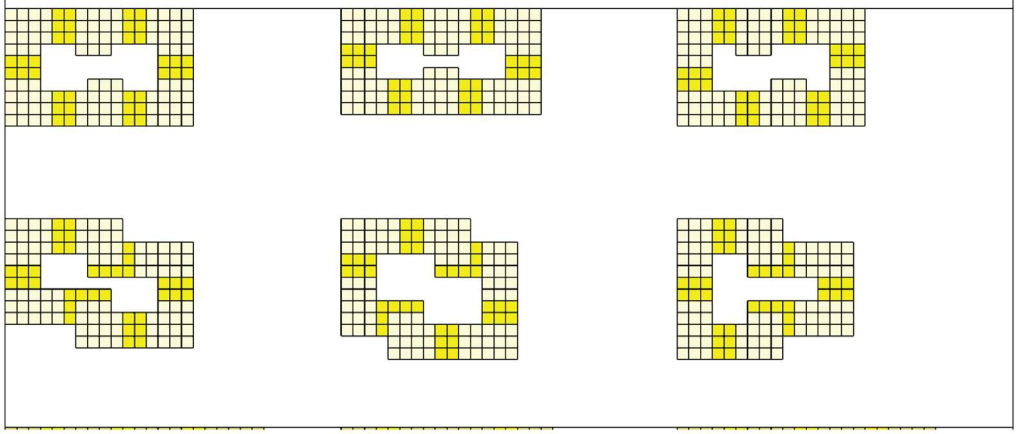
4. Clustering Example



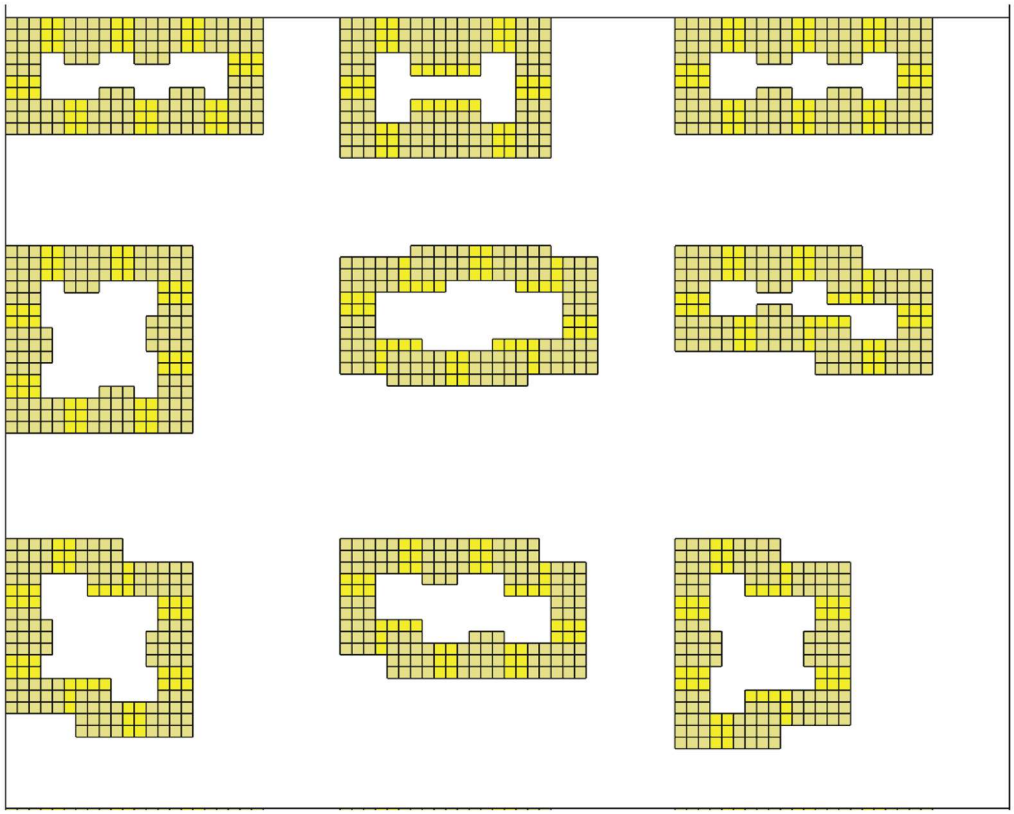
4 Household

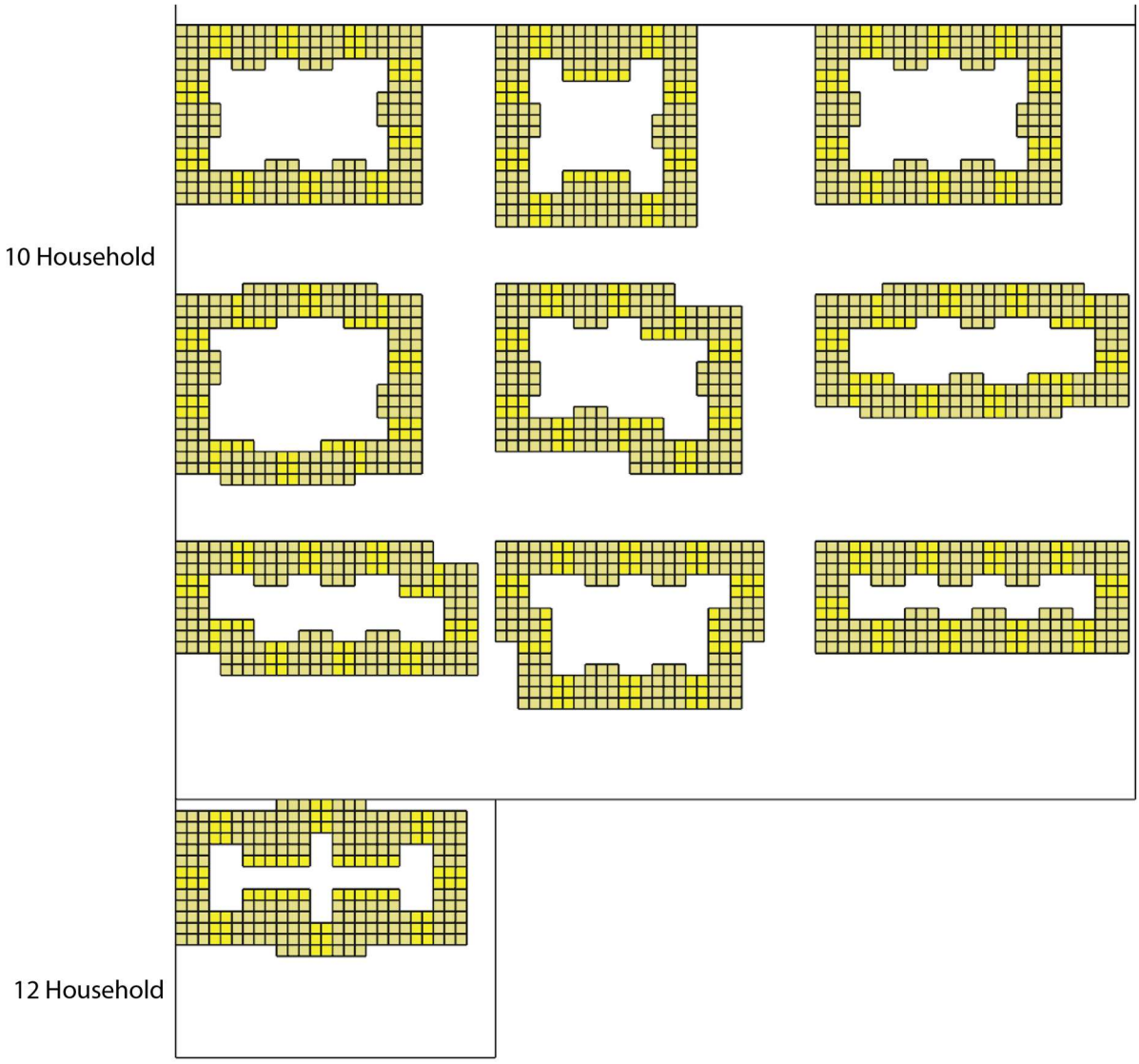


6 Household



8 Household




10 Household
12 Household