Space Utilization and Transformable Architecture of Peri-Urban Co-Living Concept in Rancaekek, Bandung

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Abstract. Peri-urban issues are generated by the problem of uncontrolled increase of settlement land-use that converts and decreases the agriculture and water absorption land-use. Development improvement is needed to support food protection and environment sustainability from urbanization pressure. Co-living Rancaekek in Bandung’s peri-urban area is a concept which aims to improve the effectiveness of land use by providing multifunctional living space and household food production through hybrid infrastructure. This residence consists of five families living together in a modular housing unit with an area of 21 m². Each unit supports families with different responsibilities: farming; food processing; capacity building; building and infrastructure management; and special units for external researchers. The analysis in this paper provides evidence that each responsibility requires specific spatial planning and multifunctional furniture that can support various activities, tools, and processes to enable adaptation in limited space. The solution to space utilization is determined through the proposed movement of furniture based on a review of transformable architecture, namely flexibility and functionality of the space being utilized, to maximize functions in a minimum size space. This research requires deeper research and/or experiments on materials, community acceptance, and a more in-depth review of furniture design in accordance with the concept of transformable architecture.

Keywords: peri-urban, co-living concept, transformable architecture

1. Introduction
Peri-urban areas can be described as the land between urban and rural areas that have mixed characteristics of both city and countryside. Therefore, urban and rural uses often clash and encourage conversion of many things such as land, profession, and infrastructure. Land conversion cannot be avoided while agricultural and water absorption land transformed into industrial and residential areas. It can be a threat for food production and groundwater availability. One of peri-urban concerns is how
to keep the agricultural land as a resource and how to keep environmental stability against urbanization pressures.

Peri-urban Co-living concept emerges as a concern to mediate agricultural rural living and industrial and service urban living. In Rancaekek, a peri-urban area of Bandung, co-living is designed to address water issues and food security by creating integrated housing with combined agricultural and service activities. This concept is aimed to reduce carbon footprint and contribute to environmental development by generating residents’ environmental awareness lifestyle. In this place, four families participate in co-living, work together to meet their needs, and share each duty. These four families inhabit identical houses which are built integrated in one common land.

However, the distinction in work roles among families poses an issue in similar occupancy, including the absence of adjustment for supporting needs that follows the duties of each family within the identical houses. The co-living design is considered flexible, where the spaces are designed to accommodate a variety of functions and are not fixated for one main function [7]. Based on these problems, the objectives in this paper is to find adjustments towards the occupancy of each family based on transformable architecture to support their lives to the fullest.

1.1 Study of Transformable Architecture
The movements in architecture can be interpreted in several perspectives to meet their purposes. The moving architecture defined in several definitions, including kinetic, responsive, transformable, and adaptable [6]. To address the limitation in space, one of the defined categories that can be utilized is transformable architecture. Transformable can be interpreted as the ability of an object to make changes to adjust to environmental conditions. So, in more detail, transformable architecture is a design that can vary according to different functions [7]. Referring to the classification made by [7], these transformations are regrouped into four objectives to address climate problems, space openness, flexibility, and functional transformability.

In the context of co-living, the concept of flexibility and functionality is chosen as an approach to solve space limitations and save extensive use of space. Flexibility is a concept of open space with the minimal partition for various functions. Meanwhile, the functional concept of transformability is a strategy to utilize space for more than one function, used at different times to save space. The difference between flexibility and functional transformability is that in a flexible space, users can use the free space for extensive functions, while in space with functional concepts of transformability, its function has been determined. However, the space can be replaced repeatedly or can be returned to their initial conditions.

1.2 Co-living Design Concept in Rancaekek Bandung
Co-living in Rancaekek is designed to attain resilience in Bandung peri-urban area. It accommodates the need for supported value, market, and ecological connectivity within the region to reach an integrated network of the social, economic, and physical for a peri-urban area. [1] The house used for this concept is located in an area of 165 m$^2$ which can accommodate four housing units measuring 21 m$^2$ with minimum border and still produce at least 66 kg of carbohydrates. The co-living house is designed to accommodate four families with shared rooms and private spaces for each family. The units of each family are arranged stacked with one another to form circulation and privacy for each unit, added with farming space to fulfill the minimum amount of carbohydrates.

The co-living experiment will be carried out by four families in four units under these hypotheses:
- Inhabiting the first floor with two units are farmer families and the family of the building management and infrastructure team.
- The second floor has two residential units which are occupied by the family who processes food and the family of capacity builder.
- The third floor has one residential unit which will be occupied by researchers.
Each family consists of four members; two adults (parents) and two children under 14 years of age. These four families have different responsibilities to maintain the sustainability of the co-living. The difference between co-living and co-housing lies in the responsibility of the family members. Families in co-housing only live together without sharing responsibilities, while families living in co-living share the responsibility to maintain the sustainability of co-living to be independent and self-sufficient. A brief description of the residents includes:

- The family of farmer has the role to plant and harvest food for consumption of the co-living families, through conventional farming, vertical farming, and roof gardening.
- The food processor family processing food from raw ingredients into consumable food to supply the five families’ nutrition.
- The family of building and infrastructure managers has the role to manage and provide the necessity needed in the infrastructure and ensure the functions running in the building and infrastructure.
- The capacity builder family has the role to improve the capacity level of soft skill and hard skill in the form of education for the families living in co-living.

The designs in this paper consist of four typical house blueprints that share similar specifications. To support the needs of its residents, on the first floor there are communal spaces, conventional gardens, car parking space and parking space for three-wheeled motorcycles. At the split level towards the second floor, there is a drying room for units on the first floor. On the second floor there are two communal spaces for joint activities while on the top floor there is a rooftop garden (fig.1).

**Figure 1. Co-living building concept**
(Source: Sobandi, 2017)

The similarity of each unit floor plan indicates flexibility of use and unspecified activities [9]. However, Rancaekek co-living concept has a specific errand for each family that promotes the needs of supporting spaces with different specifications and purposes. The complexity of requirements is the main reason for the need of variations and specification in design [13]. The specification-based design approach is often found in limited area housing design [13]. Limited area requires specific functions and reduces the possibility of space to the level that it is only provided by the designer.
Therefore, Rancaekek co-living concept design requires adjustments from a typical residential unit to a specific unit for each family, including the adjustment of furniture and layout.

2. Method
This research employs descriptive and qualitative research. Descriptive research is done by conducting simulations to obtain the idea of the setting and the activities that occur within the object of research. The description presented is a variable related to the events that occur within the object of research whereas qualitative research is concerned towards assessing and carrying out analysis based on perceptions and cognitive constructs on the object of research.

The data collection in this study is obtained through studies of archives and simulations. Literature studies are also used to understand the basic idea of the concept, starting from the background of co-living in peri-urban and its relation in a broader context, also the concept of multifunctional space. In this study, multifunctional space theory is elaborated in a discussion of the theory of transformation in architecture that examines the flexibility of space and its completeness.

Transformable architecture directs to design flexible space when users want a space not only for one function but can be easily used for other functions as well [7]. Simulation in the form of role-playing is conducted to identify the families’ daily routines in one week. Each role will further be processed into space needs that are related to flexible space theories. Functional transformability is classified again into four criteria for space saving solutions including movable functional walls, where functional components are placed in a field which can be moved indoors; function on the outside, functional components are placed in fields in the room (walls, roof or floor) to be moved manually for use; functions in the center, functional components that are stored centrally to be used by transferring to surrounding spaces; and movable walls, which divide the spaces for two functions carried out simultaneously. The four solutions are defined as ways to access various needs provided by furniture as complimentary in a space.

3. Results and Discussion
A role-playing simulation has been done as a method to collect data of all the families’ activities in a week based on their specific role and responsibility. This simulation is aimed to have an objective result from the setting and activities that occur in co-living. The result of the simulation is qualitative data that could describe the possible and suitable activity related to the families’ work function. These data are then used for the next analysis to differentiate particular spatial utilization from each family’s response to their role in co-living society.

Table 1. The schedule of daily activities for each family in one week, related to their respective responsibilities.

| Time | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|------|--------|---------|-----------|----------|--------|----------|--------|
| 05:30 | Morning workout |                 | Morning workout |         |        |          |        |
| 06:00 | Watering the plants and giving fertilizer | | Fruits and vegetables harvest | |        |          |        |
| 06:30 | Checking the mushroom’s bag log, feeding the chickens and fishes | |                   |         |        |          |        |
| 07:00 | | |                   |         |        |          |        |
| 08:00 | | |                   |         |        |          |        |
| 09:00 | | |                   |         |        |          |        |
| 10:00 | | |                   |         |        |          |        |
| 11:00 | | |                   |         |        |          |        |
| 12:00 | | |                   |         |        |          |        |
| 13:00 | | |                   |         |        |          |        |
| 14:00 | | |                   |         |        |          |        |
| 15:00 | | |                   |         |        |          |        |
| 16:00 | | |                   |         |        |          |        |
| 17:00 | | |                   |         |        |          |        |
| 18:00 | | |                   |         |        |          |        |
| 19:00 | | |                   |         |        |          |        |
| 20:00 | | |                   |         |        |          |        |

Farmer family
Food processor family
Capacity builder family,
Building manager and infrastructure family
3.1 Farmer Family
The farmer family fulfils the needs of food for all residents by utilizing the occupied land owned in the building. From what has been provided, the farmer family can manage and fulfil the number of nutritional needs for all residents. To maintain this, the farmer family is responsible for the process of planting up to harvesting food. The process of managing the land is completed through conventional agriculture, vertical farming, and roof farming. To carry out this function, the farmer family is expected to have knowledge about types of food production. They must be able to plan and manage crop-planting time, and have insights on the types of food combinations.

Table 2. Farmer family activities in a week.

| Activity                                      | Time              | Room Needed                          |
|-----------------------------------------------|-------------------|--------------------------------------|
| Watering plants and giving compost           | Every morning, one hour | Gardening equipment storage          |
| Checking the mushroom’s bag log, feeding the chickens and fishes | morning, one hour | Mushroom bag log storage, Food storage |
| Making mushroom bag log, Breadfruit or sweet potato harvest | Thursday afternoon, two hours | Gardening equipment storage          |
| Making compost, collecting wastes of dried leaves | Friday afternoon, one hour | Gardening equipment storage, waste and compost shelter |
| Fruits and vegetables harvest                 | Saturday morning, one hour | Harvesting equipment storage, harvest storage |
| Storing harvest                              | Sunday afternoon, one hour | Harvest storage                       |

3.2 Food Processor Family
The food processor family is fulfilling the nutritional needs of all residents by adding value to the crop. To do so, the farming family is responsible for the number of processed foods for a year. To carry out this function, the food processor family is expected to have the ability to process food with the skill they have, they can plan food preparation schedule and easily manage the process. The ability to process food includes knowledge about simple recipes, the ability to use cooking utensils well, the ability to store good food, as well as processing leftovers. Before the food processing process, food processor families need to have insights regarding the nutrients needed in food. During this process, this family also needs to be innovative by developing a wide range of menu for processing foods.

Table 3. Food Processor Family activity in a week

| Activity                                      | Time              | Room Needed                          |
|-----------------------------------------------|-------------------|--------------------------------------|
| Processing and storing harvest                | Monday afternoon, one hour | Food storage                          |
| Making snacks for one week                   | Tuesday afternoon, two hours | Kitchen                              |
| Processing food waste (Compost)              | Friday night, one hour | Compost storage                       |
| Cooking meal for everyone                    | Saturday afternoon, one hour | Communal room                        |
| Storing harvest                              | Sunday afternoon, one hour | Harvest storage                       |

3.3 Building and Infrastructure Manager Family
The building and infrastructure manager family has the role to provide the infrastructure needed by residents and ensure that the infrastructure and building system run well. This family has the
responsibility to control the building maintenance, including piping, electricity, building construction, and the use of hybrid technology needed for efficient and sustainable water and electricity. The technology used includes solar panels, drip irrigation systems, and rainwater harvesting. There are two types of control that must be done including preventive maintenance as a routine and preventive maintenance control; cleaning, inspecting, adjusting, updating, etc., and corrective maintenance, which is a repair, removal, replacement, or modification of damaged items or systems. This routine is done twice a week (corrective maintenance). Besides, this family has the chance to seek extra income as a handyman available for the community as well as construction and building consultant.

### Table 4. Building and Infrastructure Manager Family’s Activity in a week

| Family                            | Activity                                      | Time                  | Room Needed          |
|-----------------------------------|-----------------------------------------------|-----------------------|----------------------|
| Building and Infrastructure       | Preventive Maintenance #1                     | Monday morning, one   | Tools storage        |
| Manager Family                    |                                               | hour                  |                      |
|                                   | Preventive Maintenance #2                     | Friday afternoon, one | Tools storage        |
|                                   |                                               | hour                  |                      |
|                                   | Corrective Maintenance #1 and #2              | Saturday afternoon,   | Tools storage        |
|                                   |                                               | one hour              |                      |
|                                   | Watering plants by drip irrigation system     | Everyday (automatically) | Tools storage      |
|                                   | Processing grey water and rain water         | Everyday (automatically) | Gray water   |
|                                   | harvesting                                    |                        | storage tank        |
|                                   |                                               |                        |                      |

### 3.4 The Capacity Builder Family

This family is the initiator of the residents' communal activities to improve the quality of social relations between each family, children's education related to the importance of food security, and hard skill training to carry out necessary practices such as gardening, food production, treatment, and life skills that can be used daily. In addition, this family also has the role of conducting quality improvement education on health, soft skills, intrapersonal communication, and interpersonal communication. The form of activities that can be carried out for capacity building is in the form of training, courses and workshops and activities that actively involve all residents of co-living, such as exercising, watching movies together, and cooking. A health control system can be done by working together with local health clinic (posyandu).

### Table 5. The Capacity Builder Family’s Activity in a week

| Family   | Activity                                      | Time                  | Room Needed            |
|----------|-----------------------------------------------|-----------------------|------------------------|
| Capacity | Morning Workout                               | Sunday morning        | Communal room          |
| Builder  |                                               |                       |                        |
|          | Education on gardening for children and       | Wednesday and Friday  | Communal room          |
|          | parents                                       | afternoon              |                        |
|          |                                                 | Books Storage         |                        |
|          | Health Check                                  | Sunday afternoon      | Health equipment       |
|          |                                               |                       | storage                |
|          | Assisting Karang Taruna                       | Sunday afternoon      | Communal room          |
|          |                                               |                       |                        |
|          | Life-skill workshop                           | Saturday night        | Workshop equipment     |
|          |                                               |                       | storage                |
|          | Barbeque                                      | Saturday night        | Communal room          |
|          |                                               |                       |                        |
|          | Watching movies together                      | Saturday night        | Projector storage      |
|          |                                               |                       |                        |
All results of the analysis of space requirements in each family are combined to obtain a space utilization solution that refers to the Reuter classification. Adapted to the needs of the activity, this classification provides furniture solutions with suggestions for the space needed and possibilities of furniture’s movement to save space. The wide range of the movement possibilities from one to another is needed to fulfill the space-saving requirements of furniture suitable for each family to do their activities.

| Family          | Room needed          | Suggested area for storage                          | Space-saving solution         | Possible movement |
|-----------------|----------------------|----------------------------------------------------|--------------------------------|-------------------|
| Gardening       | Inside or outside the housing unit | Movable functional walls                        | Slide                          |                   |
| Mushroom bag    | Yard or communal room | Functions on the outside                           | Swivel                         |                   |
| Food storage    | Yard                 | Functions in the center                           | Slide                          |                   |
| Compost waste   | garden, yard, communal room | Movable functional walls                        | Slide                          |                   |
| Harvest storage | Rooftop garden, garden | Functions on the outside                           | Flap                           |                   |
| Food storage    | Kitchen              | Movable functional walls                           | Fold                           |                   |
| Cooling equipment storage | Inside housing unit (kitchen or family room) | Functions on the outside | Fold | |
| Food Processor  | Kitchen              | Functions on the center                           | Slide                          |                   |
| Compost Storage | Conventional garden  | Functions in the center                           | Slide                          |                   |
| Cooking meals   | Communal room and garden | Movable walls                                 | Fold                           |                   |
| Harvest room storage | Communal room | Movable functional walls | Slide | |
| Building and Infrastructure Manager | Communal room | Movable functional walls | Rotate | |
| Tools equipment storage | Outside housing unit, outdoor, children are unable to access | Movable walls | Fold | |
| Gray Water storage tank | Inside housing unit, outdoor | Movable walls | Fold | |
| Rainwater storage tank | Indoor communual room | Movable functions | Slide | |
| Communal room   | Outside housing unit, outdoor | Movable walls | Fold | |
| Books storage   | Indoor communual room | Movable functional walls | Slide | |
| Health equipment storage | Indoor communual room | Functions on the outside | Slide | |
| Workshop equipment storage | Communal room | Movable functional walls | Slide | |
| Projector storage | Indoor housing unit | Functions on the outside | Slide | |

4. **Conclusion**

Based on the simulation that has been done, the design of a typical flexible space has not been able to accommodate the activities of Co-living occupants. The adjustment of Co-living’s residential in Rancaekek can be done with the concept of functional transformability, which is a concept of adapting the use of space for various functions. This concept requires a transformation of functional space into another required space that is further continued by analyzing its furniture needs. In the adaptation,
multifunctional space requires furniture with the criteria that suit best with transformable architecture solutions and the proposed transformation. The results of this study indicate that a typical unit plan on the Rancaekek co-living concept should be supported by furniture designs that fit the criteria of functional transformability. The design of furniture is made specifically for each type of family based on their work. Therefore, we recommend further research on furniture design that is suitable to the criteria required for Rancaekek's co-living stakeholders. In addition, experiments are also needed regarding furniture materials and community acceptance towards this concept.

Solution of transformable architecture’s flexibility and functionality for co-living design in Rancaekek Bandung is a part of social concern exercise into built environment design. The social puts-built environment design not only concern about form and technical matters, but also about how design becomes an effort to provide human right through involving and empowering the societies [10] [8], [4]. Social space produced by architectural design represents the human complex social desire for a better future (2010:29613). Here, architecture becomes relational, as mediator for social action programs by shaping, conditioning and facilitating the possible sociality [12].

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