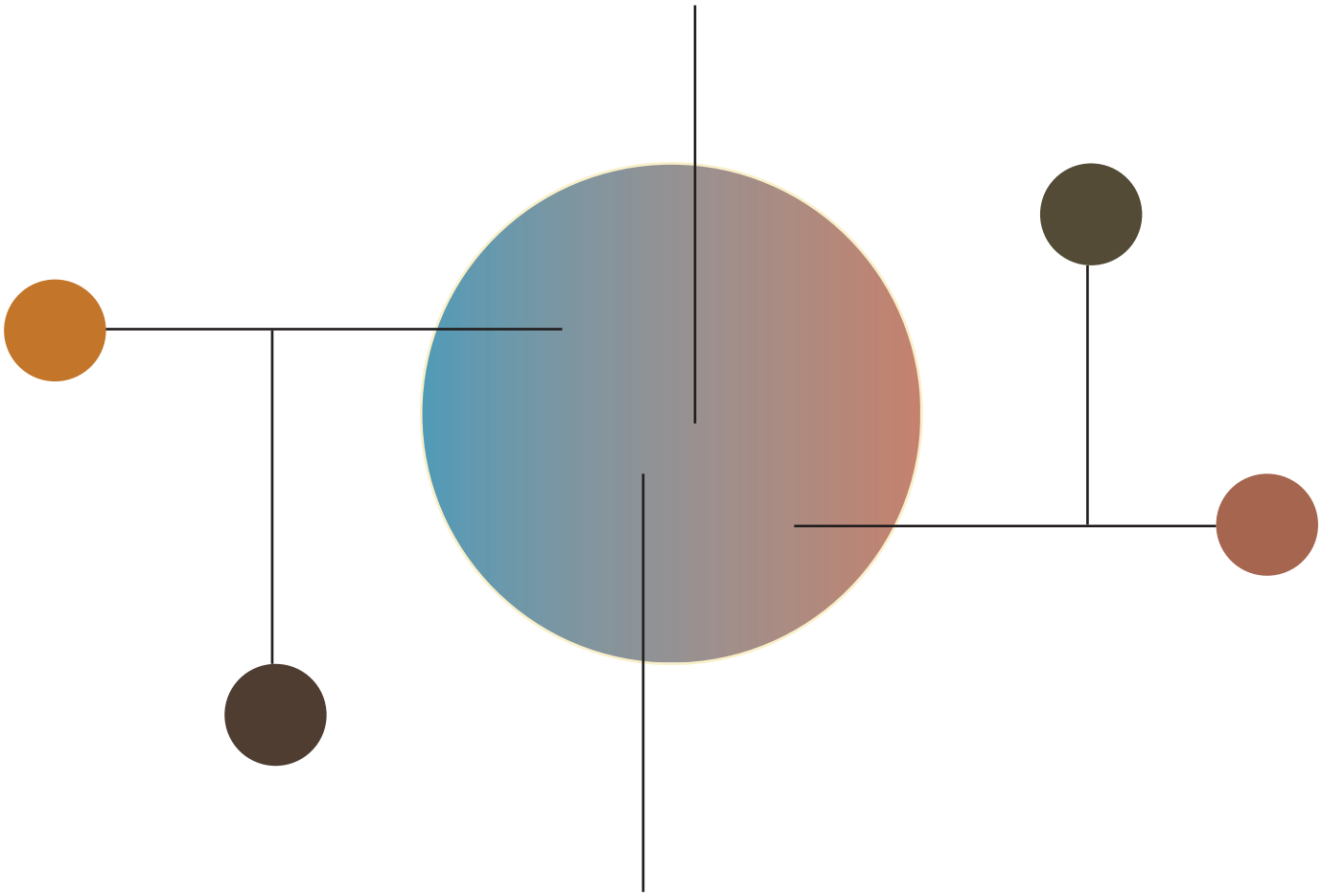
TRANSDISCIPLINARITY WITH CONTRADICTIONS

THROUGH A SUSTAINABLE ENERGY CO-INNOVATION HUB IN KIGALI



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Master program of Architecture and Planning Beyond Sustainability (MPDSD)

Master Thesis_Urban Challenges_Spring 2020

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ABSTRACT

This thesis is an exploration of the ways in which design can promote and steer co-innovation and co-learning among different facets of academia and education. It is essentially a study on a transdisciplinary approach through architecture. The analysis part of this research was based on three theories; Quadruple helix, Architecting Interaction, and Interdisciplinary Research in order to frame how to stimulate an innovations system by employing a transdisciplinary approach. Transdisciplinarity in this context is interpreted as a co-learning process between different actors aiming to invent a comprehensive innovation system. In turn, co-learning means that those different actors have mutual/bidirectional exchanges of expertise and ideas each drawing from their respective fields of knowledge, skills, and cultures. Therefore, designing the spatial context to encourage this bidirectional exchange becomes the key research question; 'How can design promote 'Bidirectional Learning between different actors in the educational sphere?'

The case study of the thesis is situated within the East African context. Initiated by the SIDA (The Swedish International Development Cooperation Agency) Funded-Partnership, this thesis is part of a collaborative pilot project between Chalmers University of Technology and the University of Rwanda. The project is about re-inventing the African Center of Excellence in Energy for Sustainable Development (ACE-ESD) in order for it to eventually become a co-innovation hub for sustainable energy and growth, especially in Rwanda. The critical challenges and contradictions this project faces are the fragmentation of the four sectors in the Quadruple helix model; the initial actors belong only to the academic sector and are monodisciplinary. Additionally, the Rwandan social structure is characterized by acute hierarchies and inequality which influences the relationship of the actors and their pattern of learning as dominant and subservient.

A Co-Innovation hub should be a co-learning space aiming to equally include a variety of academic and non-academic fields. Based on what the particular context of this case study entails, the challenges and contradictions mentioned above become a core design concept. In a way, the coexistence of contradictions and their intersections are perceived as a value. The theories studied in the analysis part and the duality of the contradictions were turned to be a design strategy through the architectural materiality and immateriality.

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Introduction

Multi- / Inter- / Transdisciplinarity

Multidisciplinary research involves more than one discipline but without producing merged conclusions.

Interdisciplinary research draws information and data from different academic disciplines and the results are merged.

Transdisciplinary research is a collaborative process, resulting in merged knowledge from different academic disciplines as well as stakeholders outside of the academic world. The problems and solutions are jointly determined.

These descriptions of Multi-, Inter-, and Transdisciplinarity are defined differently by different researchers. Transdisciplinarity in this study follows the definition found in the book 'An introduction to Interdisciplinary research' (2016).

This research intends to focus on Transdisciplinarity because the Transdisciplinary approach has been broadly used by many fields of research, including those of Architecture and Construction. The participation of the community has been an increasingly popular concept in the architectural design process, from interior design projects to city planning. The different voices within a community are getting increasingly important when it comes to seeking innovative solutions.

On the other hand, there are also several challenges stemming from the complexities within the project as well as from external factors dictated by the project's context. The cultural differences resulted in the forming of a key question for this study, in terms of academic and non-academic ways and norms. In our globalized world, we design across borders and boundaries, in diverse contexts employing a variety of disciplines. This architectural research aims to drive and encourage architects to be aware of that, and explore the ways in which they could be prepared to work with all the differences.

As Jeroen van Dongen, professor of science at Utrecht University and the University of Amsterdam, stated in 2013 in his book "An Introduction to Interdisciplinary Research: theory and practice"

> "When you study, you submerge yourself in the culture of that discipline. You learn not only its knowledge but also its cultural values and norms. In interdisciplinary research, talking with someone from another discipline means you are meeting someone from another culture. When doing so, you have to 'a-culturalize' from our disciplinary background".

MASTER THESIS OVERVIEW

A co-innovation hub project in Kigali, Rwanda, is the case study to investigate the transdisciplinary approach in architectural design. In general, transdisciplinarity is implemented as a new method of finding innovative solutions to complex current and future challenges. This case study operates in the energy sector following a national agenda. It is dealing with complex social and environmental challenges, as well as economic issues with a goal to devise better and more holistic supporting systems and strategies. In an attempt to answer the main research question on how design can encourage transdisciplinarity, the initial analysis of the master thesis was framed through three theories; Interdisciplinary research, Quadruple Helix, and Architecting Interaction.The expected result is a design proposal and a strategy on how to foster a transdisciplinary approach, as a tool to deal with contemporary and future complex challenges.

Case Study

Kigali Innovation Hub

What is it ?
- Research & training Center in renewable energy sector

What will happen there ?
- The research&training, and new incubator center

What does it look like(now) ?
- An existing building with divided rooms and adding new tools and furnitures without natural light and flow of activites.

Who is it for(now) ?
- Academic disciplines, in Rwanda and Sub-sahara Africa

Goal ?

Create innovations and relationships that will implement and/or meet UNSDGs and African's Agenda.

Complex Challenges:

- Inclusive development,and people-driven, especially women and youth, and caring for children
- An integrated continent, politically and good governance
- Saving and developing cutural identity and values, also as a global player and partner.
- A peaceful and secure continent

+

Research Question

How can design promote 'Bidirectional Learning' between different actors in educational space?

Models

A Interdisciplinarity
B Quadruple Helix
C Architecting Interaction

Outcome

What design element can foster transdisciplinarity to deal with the complex challenge and reach the goals

A Different disciplinary methods; Multi-, Inter-, and Trans,are needed in order to innovate the solutions for complex problems

B Bidirectional interactions between four major actors; Governace, Society, Business,and Academic to drive the innovation system

C Context to foster interactions through creativity, collaboration, and learning. Also, a collaborative approach.

Figure 1.1. Master thesis overview diagram

MASTER THESIS STRUCTURE

The master thesis process follows what the author calls 'Circular process.' The circular process is the merging of a theoretical scientific method from the book "An Introduction to Interdisciplinary Research: Theory and Practice" and a conceptual collaborative design process from the book "Architecting interaction: How to innovate through interaction". The circular process is in fact an iterative process with much back and forth studies between theory and testing in order to to move forward the architectural design. The study and analysis process is repeated in three phases, which are illustrated as three different phases in this Master thesis booklet plus the introduction at the beginning and reflections in the last part. The first phase is the 'Analysis' conducted in order to delve into the topic of transdisciplinarity and get familiar with the case study. The second is about the formulation of a 'Concept' to translate all the information gathered through field research into a design concept. The third phase, or 'Design', is about implementing the conceptual design onto the existing structures of the case study, while simultaneously framing the design strategy reflected on this very concept implementation.

Apart from the aforementioned, there is a 'Co-Design' process running in parallel with this thesis; it is part of a collaborative project between Chalmers University of Technology and the University of Rwanda. The 'Co-Design' part is included in Phase 2: Concept I Reality 02.

Figure 1.2. The four steps of cirular process

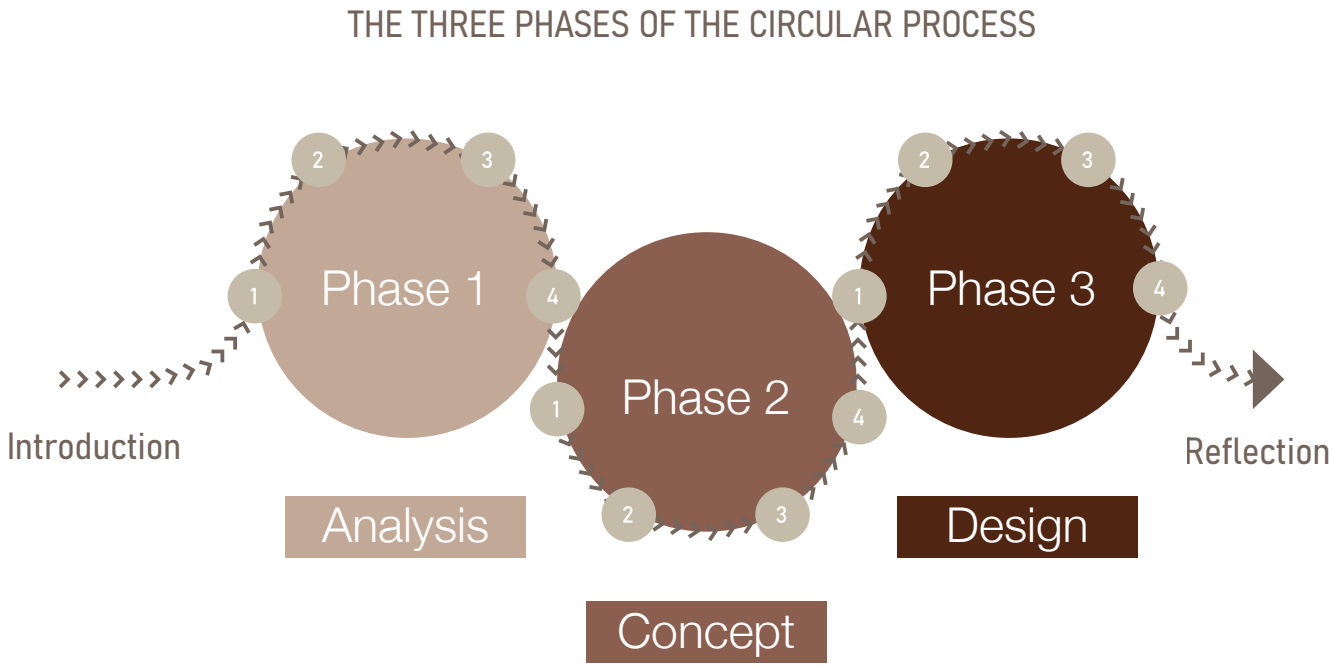


Figure 1.3. Master thesis structure diagram

Phase 1 - Analysis

Theories 01

The theoretical scope and requirements to reach a Transdisciplinary approach.

Additionally, a preliminary study of the stakeholders and the location of the case study for a robust overview before conducting field research.

FROM TRANSDISCIPLINARITY TO INNOVATION

The transdisciplinary approach has been applied increasingly outside academic research and into practices. It is a holistic approach that aims to improve the understanding of complex problems, primarily revolving around social issues. Participation under the umbrella of transdisciplinarity has all types of actors, even people outside the academic or scientific professions. In order to achieve a deeper understanding of the complexity of the issues at hand, while exploring new solutions, practical and local knowledge are included in the process. In other words, this approach is leading to 'Innovation' that is highly contextualized and therefore desirable and efficient in particular regions, social values, and norms.

This research began with theoretical studies. The Quadruple Helix model helped in categorizing the actors; Academia, Business or Industrial, Public sector, and Society (Schütz, F., Lena Heidingsfelder, M., and Schraudner, M. 2019)(Stehn, Amanda. 2014). The master thesis process planned to have the 'Circular process' as defined in "An Introduction to Interdisciplinary Research" (Menken, Steph. and Keesta, Machiel. 2016) and "Architecting Interaction" (Akkaoui Hughes, Stephanie. 2016).

After the theoretical studies, the case study's background underwent a preliminary analysis in terms of the stakeholders and the site itself studied and analyzed before moving forward to the field research in Kigali, Rwanda for six and a half weeks.

FOUR SECTORS OF QUADRUPLE HELIX

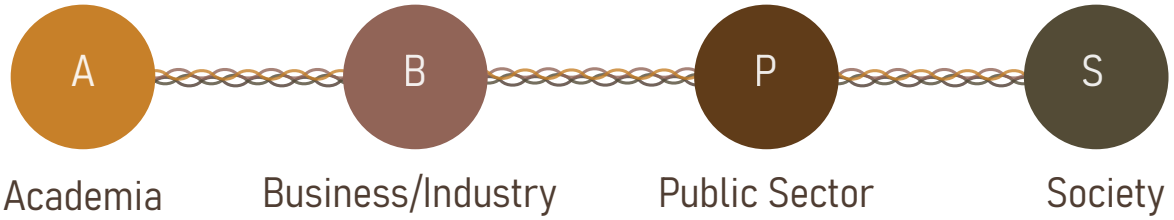


Figure 1.4.1. Four sectors (typology of actors) in the Quadruple Helix theory

These sectors of actors refer to the Quadruple Helix model. The previous model was the Triple Helix concept, as analyzed on a paper by Henry Etzkowitz and Loet Leydesdorff in 1995 (Leydesdorff, L. and Smith H.L., 2012). The Triple Helix is a model used when aiming for innovation in terms of fostering technological and economic growth that involves three different key actors; the Academic, Business (or Industry) and Public sectors. The Triple Helix was later on developed further to highlight the potential role that civil society could play. The inclusion and participation of Society as a fourth helix becomes an additional key element in creating the innovation system to share the information, knowledge and skills that create comprehensive, implementable, and practical solutions. The quadruple Helix has been transformed based on different aspects from different authors; one of them is the Quadruple Helix by Elias G. Carayannis and David F.J. Campbell in 2009. The innovation system by integrating Cultural-based and Media-based perspectives, relates to the cultural values and lifestyles; multiculturalism and creativity. The “Society” or “Public” was introduced as an important holder and a sharer of knowledge.
According to Carayannis et al (2012) “Knowledge, as a resource, is created through creative processes, combinations, and productions in so called ‘Knowledge models’ or ‘Innovation models’ and thus becomes available for society” (p.16-17).

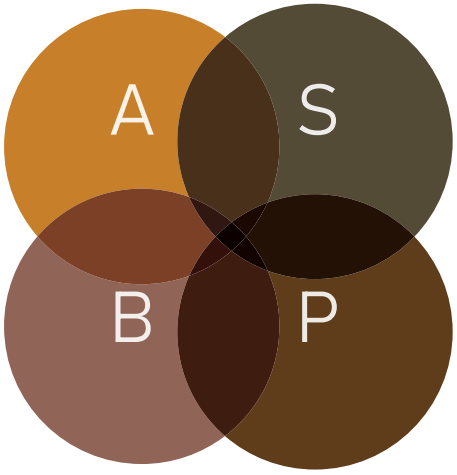
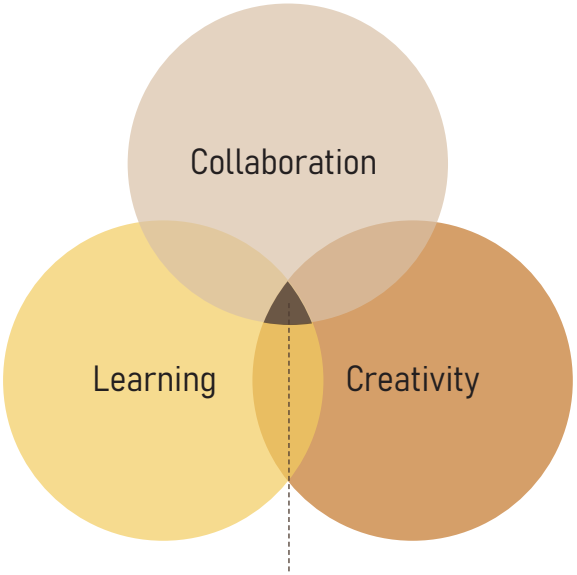


Figure 1.4.2. Interaction of the four sectors of actors in Quadruple Helix theory.
Adapted from the masters thesis Transition Hub by Stehn,A. (2014).

THREE FORMS OF INTERACTION



"Interactions are the seeds of innovation"

Figure 1.5. Three Forms of Interaction.
Adapted from Architecting Interaction by Akkaoui Hughes , S. (2016).

Stephanie Akkaoui Hughes, in her 2016 book "Architecting Interaction: How to innovate through interactions", states that the main global challenge we're facing nowadays is fragmentation. The complexity level of issues relating to economy, politics, natural and human resources as well as the environment is rising, and it is not possible for those issues to be solved by fragmented thinking. What is needed is comprehensive thinking, and collaboration in order to generate new answers and new solutions. "Yesterday's answer does not address today's questions. We need new answers; we need to innovate [...] Comprehensive innovation can never happen without human interaction. Interaction is the seeds of innovation. More specifically, comprehensive innovation is driven by three forms of interaction: collaboration, creativity, and learning" (Hughes, S. A. 2016, p.27,33). Even though there are various types of interactions and human relationships these days, this theory along with this thesis's research question, share the objective of pushing forward the quest for innovation with a holistic approach. This is why the three forms of interaction by collaboration, creativity, and learning will be a focal point in this study.

CIRCULAR PROCESS

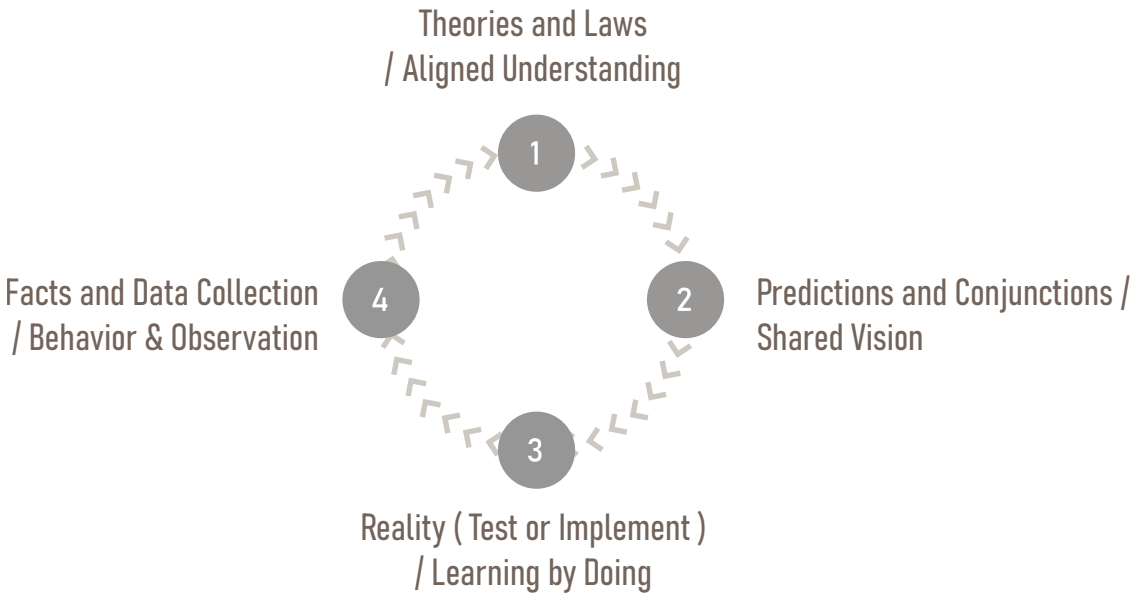


Figure 1.6. The diagram of circular process

The four steps of the circular process is an approach for collaborative projects and is referring to two theories. The first theory is based on the Scientific Method with three additional steps integrated in the process; add, adjust, and connect (Menken, Steph. and Keesta, Machiel. 2016). The other one presents the four steps on how to research and design with(in) a cross-disciplinary collaborative process. This second theory is based on the notion of “Design Thinking process” (Akkaoui Hughes, Stephanie. 2016). By comparing the two approaches, one can acknowledge that they are headed towards a similar direction, with the only differences being the phrasing and the details.

Interdisciplinary Research with Scientific Method

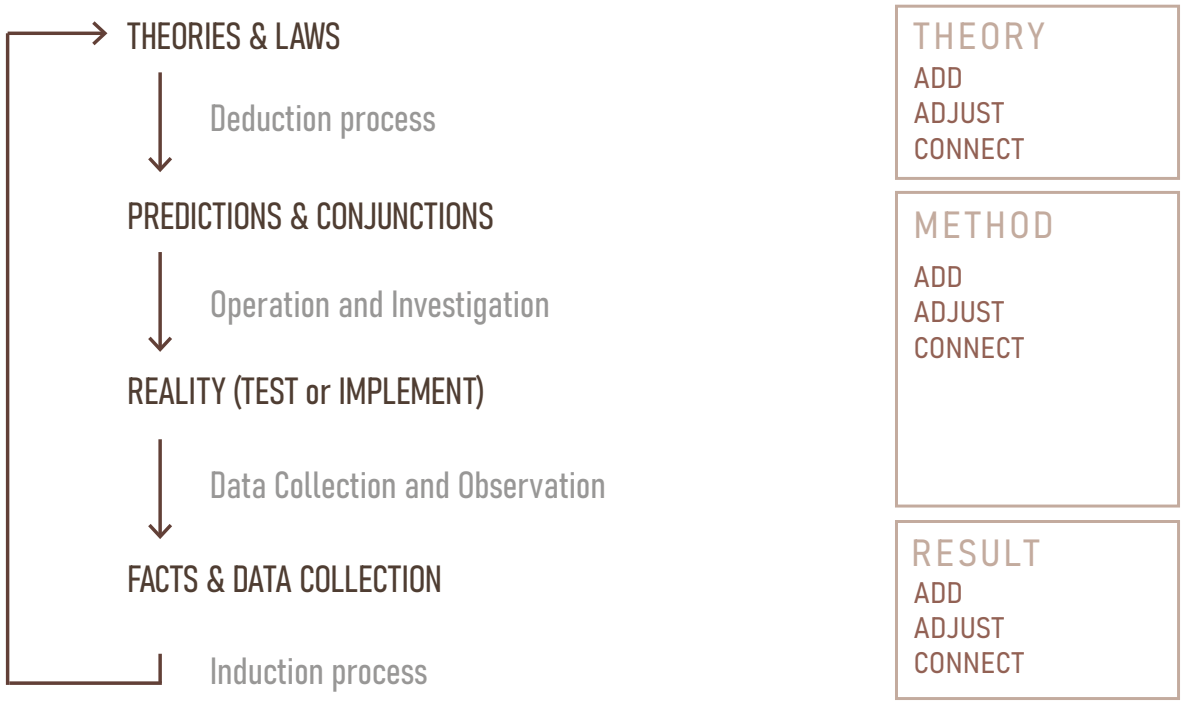


Figure 1.7.1. The diagram of a circular process. Adapted from the book An Introduction to Interdisciplinary Research: Theory and Practice by Menken, Steph. and Keesta, Machiel. (2016).

Designing with Collaborative Process

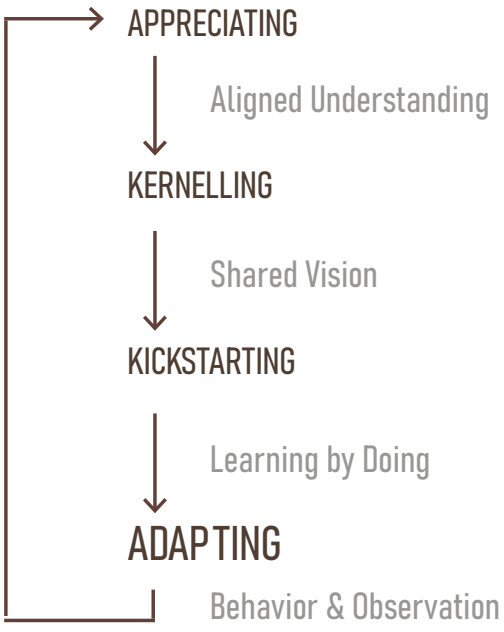


Figure 1.7.2. The diagram of a circular process. Adapted from the book Architecting interaction: How to innovate through interaction by Akkaoui Hughes, Stephanie. (2016).

PROJECT STAKEHOLDERS

The Co-Innovation Hub project was launched under the SIDA fund-partnership (The Swedish International Development Cooperation Agency) and is a collaboration between Chalmers University of technology and the University of Rwanda, 2019-2024. Coming from both universities, the primary stakeholders and team leaders had been planning this project for a long time and started to formulate the official project plan in 2019. They initiated an action plan about co-designing and re-imagining together the existing ACE-ESD center building. The design of the hub is a plan for future collaborative research, innovation, and entrepreneurship in sustainable energy between the two universities. The co-design team, established in November 2019, is composed of a Master thesis student (the author of this thesis) from the Department of Architecture and civil engineering, Chalmers University of Technology, and three Bachelor Thesis students from the School of Architecture, University of Rwanda.
The aim of the initial stakeholders is to not limit innovation only within the framework of the academic research on the energy sector, but rather to provide a building design that can be inspirational and attract new people -outside of academia- pursuing further opportunities and connections

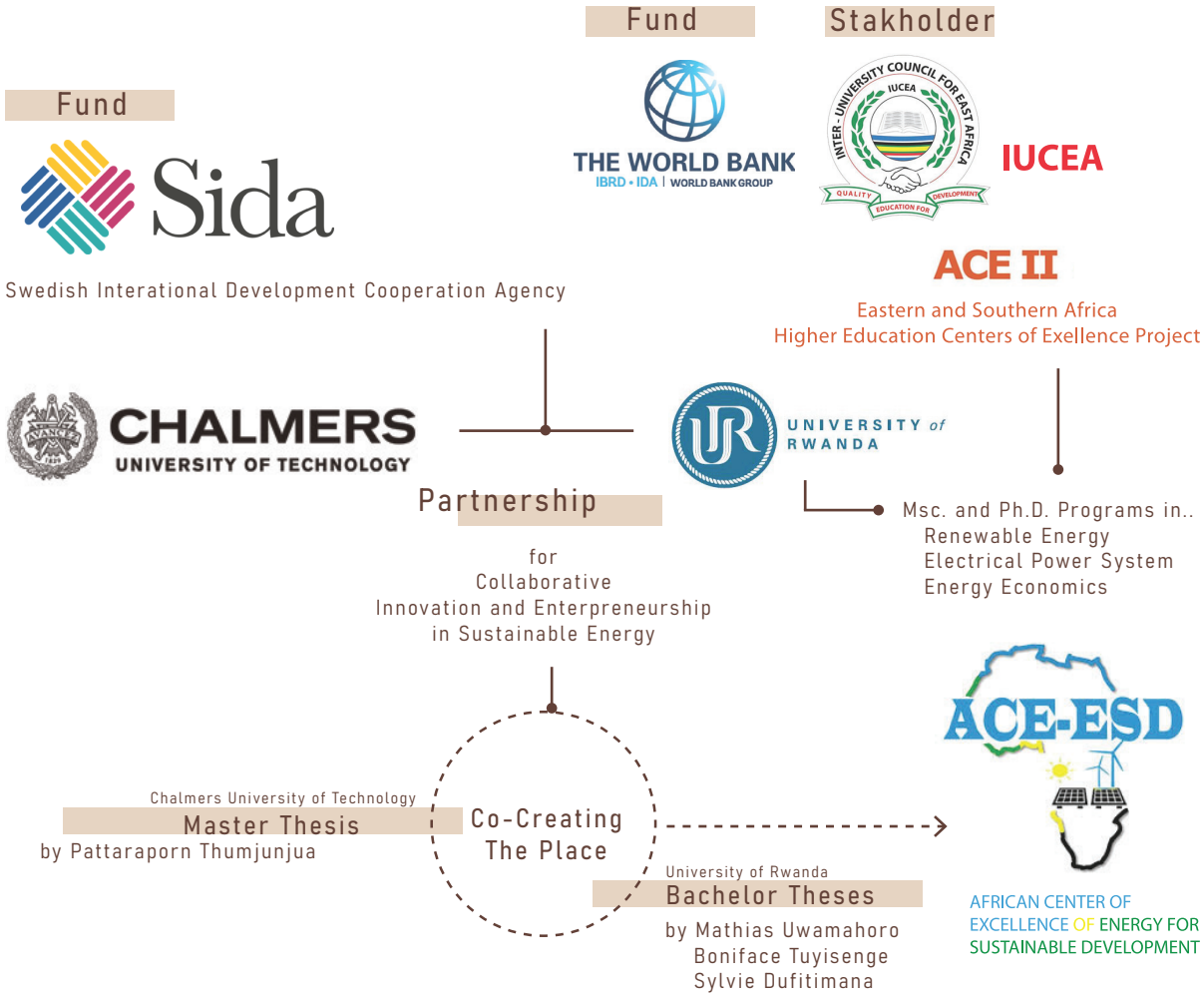


Figure 1.8. The diagram of project stakholders

PROJECT LOCATION

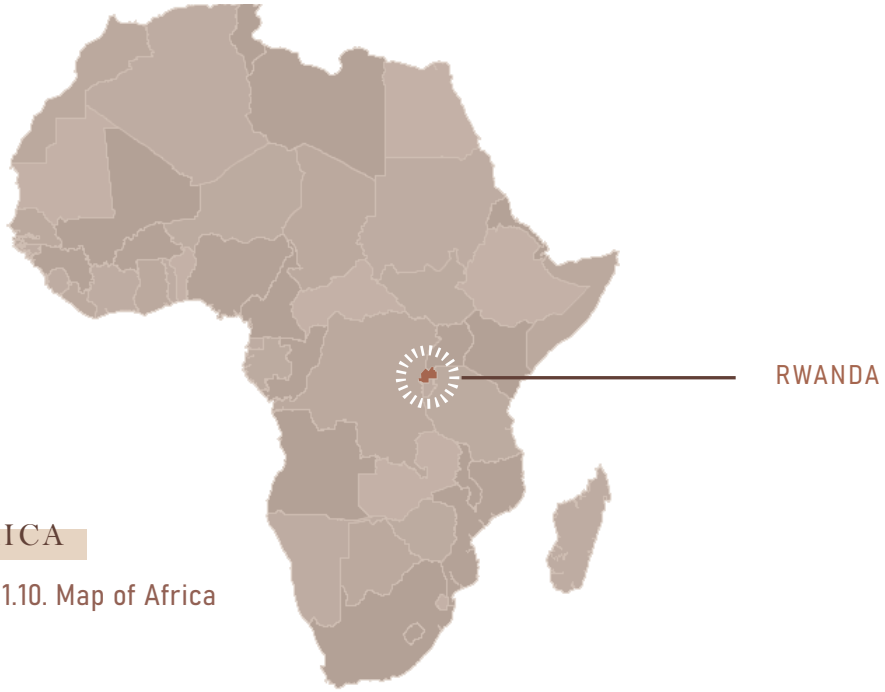
According to global sustainable development, Rwanda is a country in Africa that has exhibited an excellent performance in economic growth. After the (devastating) genocide in 1994, Rwanda was faced with the collapse of its socio-economic structure. According to "Vision 2020", a part of Rwanda's national agenda as of 2000, one of the most important goals, especially after facing the consequences of the genocide, has been to rebuild human rights and restore the rule of law. Rwanda has since seen a positive annual growth of 8%. As a further step, Rwanda launched a new national development agenda, a draft "Vision 2050", otherwise known as "National Strategy for Transformation" (NST1, 2017-2024). The NST1 is the result of the merging of the African Agenda 2063 and UN Sustainable Development Goals (SDGs) 4, 8, 10, 13, 16, and 17.

The African Agenda 2063 aspirations:

1. A prosperous Africa based on inclusive growth and sustainable development
2. An integrated continent politically united and based on the ideals of Pan-Africanism and the vision of Africa's Renaissance
3. An Africa of good governance, democracy, respect for human rights, justice and the rule of law
4. A peaceful and secure Africa
5. An Africa with a strong cultural identity, common heritage, shared values and ethics
6. An Africa whose development is people-driven, relying on the potential of African people, especially its women and youth, and caring for children
7. An Africa as a strong, united and influential global player and partner

UN Sustainable Development Goals (SDGs) 4, 8, 10, 13, 16 and 17;

Figure 1.9. Relevant Sustainable development goals in Rwanda Agenda 2050 by the United Nations Sustainable Development Goals

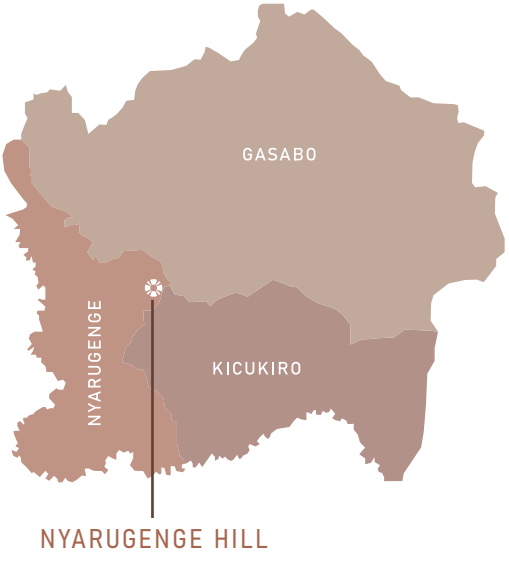


AFRICA

Figure 1.10. Map of Africa

RWANDA

Figure 1.11. Map of Rwanda



KIGALI CITY

Figure 1.12. Map of Kigali city

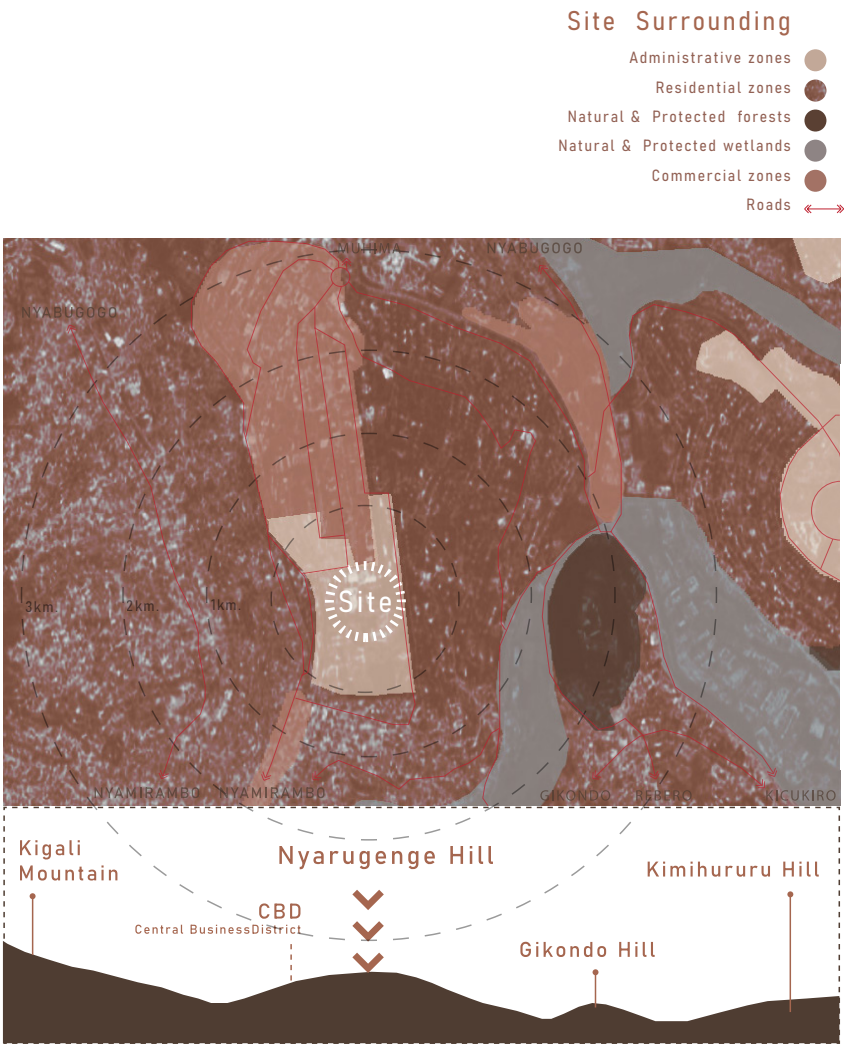


Figure 1.13. Project location and the surrounding

The African Center of Excellence in Energy for Sustainable Development (ACE-ESD) is an organization aiming to address Africa's critical challenges within the economy and renewable energy technologies in the East and Southern Africa region, especially in Rwanda, and achieve an accessible and affordable clean energy service. The center uses sustainable energy as a means to stimulate economic growth, and thus reach social equity and environmental sustainability. Therefore, the ACE-ESD aims to create a place that will foster innovation in energy research as well as provide training for people to acquire the necessary skills for generating critical solutions that will contribute to achieving the national and regional goals of the NTS1.

Since the case study is situated in Rwanda, socio-economic growth is at the very heart of this project. However, even though the development of relevant technologies and innovations is being promoted as a tool to reinforce Rwanda's socio-economic structure, the link connecting the innovative systems to civil society is still weak. As previously suggested, what is needed to mend this link is a more holistic and collective approach.

Prediction 01

This phase is about creating a comprehensive innovation system through a combination of the three principles deriving from the theoretical study; the four different actors of the quadruple helix, the circular process and the interactions in their three previously defined forms; collaboration, creativity, and learning.

A COMPREHENSIVE INNOVATION SYSTEM

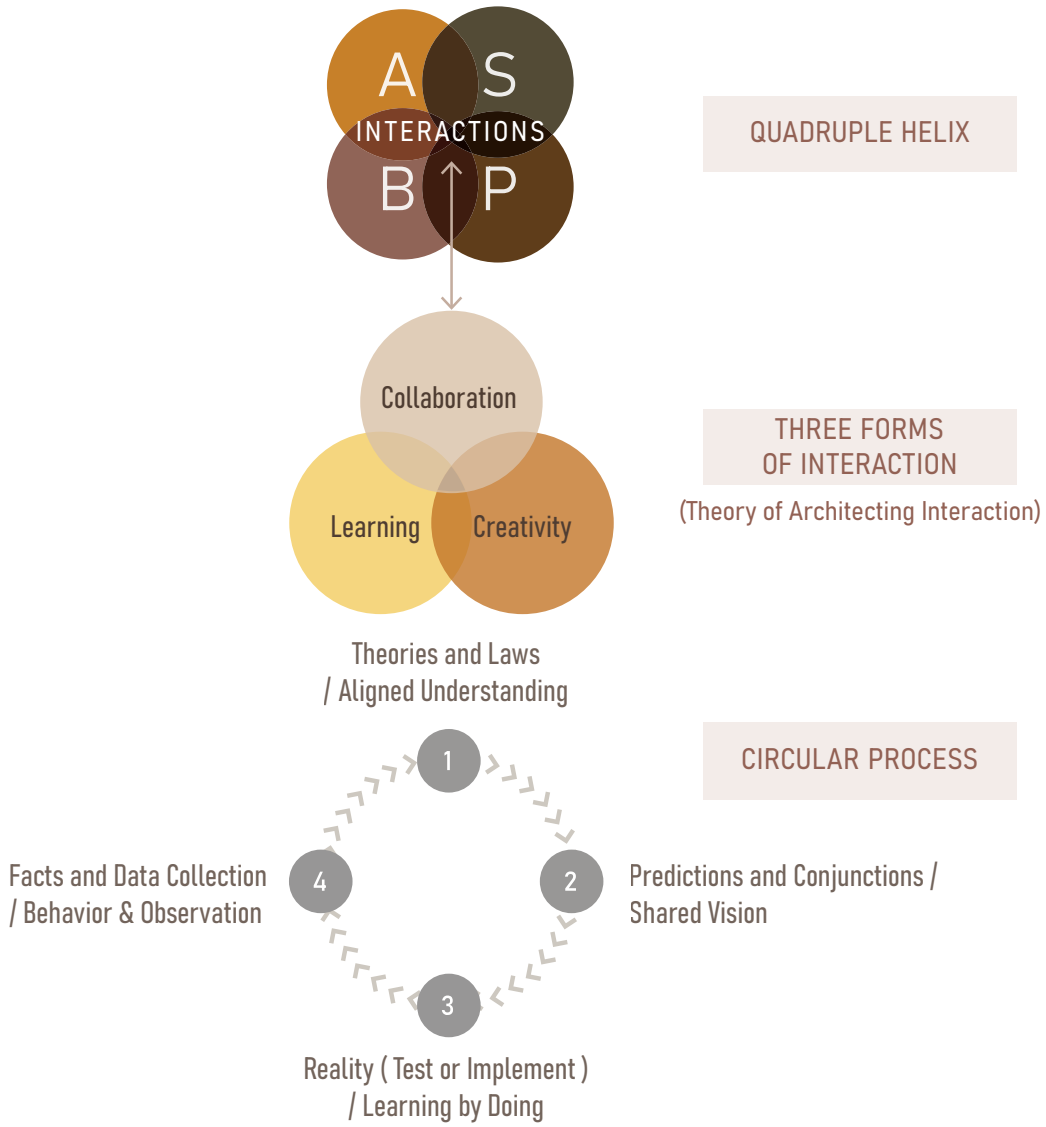


Figure 1.14. The diagram of a comprehensive innovation system

The quadruple helix is an innovative system model in which different actors within Academia, Business, the Public sector, and Society come across, and it illustrates the interactions between scientific professions and the general public. There is room for developing various forms of interaction. As mentioned in a previous chapter, according to "Architecting Interaction", there are three different types of interaction; collaboration, creativity, and learning. The Circular Process, which was the outcome of the merging of two theories, falls in place as the means to circulate the participation of the actors from the four different sectors. The assumption is that the 'comprehensive innovation system' to be developed, should create a collaborative learning environment where all the actors from the four sectors can exchange data resources, knowledge, experience, and reflect on any problems. This exchange, as a form of a bidirectional relationship focused on learning, is supporting the growth for every sector of the innovation system to improve their problem-solving capacity when it comes to developing comprehensive, desirable, and resilient solutions.

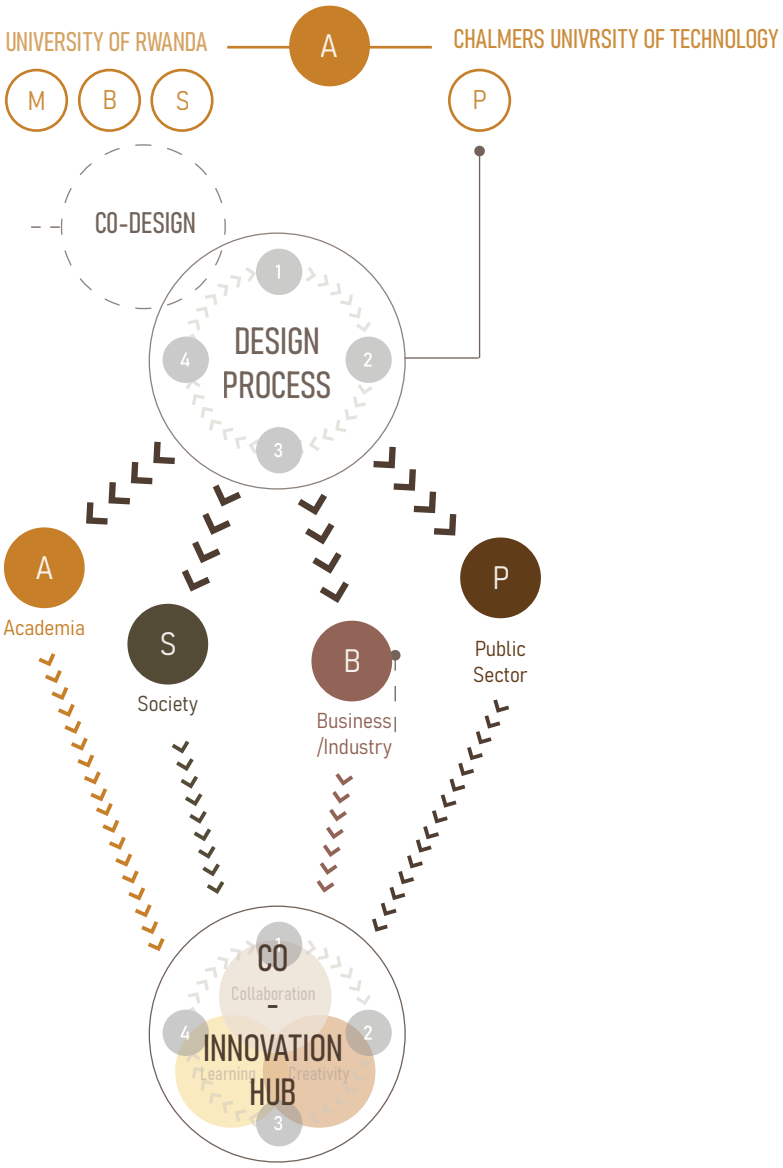


Figure 1.15. The diagram of the research by design process

METHODOLOGY

As research by design, the theoretical study and the initial prediction need to consider the actual actors' inter-relations and their conditions within the Rwandan context. The field research was planned as an iterative design process.' This process was a step towards understanding the learning and working cultures of the actors from the four sectors and their potential to engage in collaborative learning as active participants. Moreover, there was a parallel process of the Co-design team together with the architectural bachelor thesis students from the University of Rwanda. The involvement of the Co-design team in this study was a chance to experiment on the circular process within the multicultural squad, since the author has experience on the Thai and Swedish contexts, while the other three members have an in-depth knowledge of the Rwandan context.

Reality 01

Field research in the city of Kigali in Rwanda, a primary observation and some interviews; these were used during the preliminary investigation in order to answer the questions and the predictions.

In the beginning, the field research in Kigali was planned for eight weeks with the goal to investigate the application of the previous theoretical studies and the predictions of the 'comprehensive innovation system' within the actual context of the case study. In parallel with this investigation, the ACE-ESD team and the Co-Design team were experimenting with the circular process. Eventually, the field research in Kigali was shortened to six and a half weeks, because of the COVID-19 pandemic.

The field research in Kigali started on February 3rd, 2020. The first two weeks were mainly dedicated to primary observation. It was an opportunity to immerse in and appreciate the city and the Nyarugenge campus, where the ACE-ESD center is located. This phase was an investigation of the predictions and a double-checking of the information gathered during the pre-study. The process was not linear as there was a significant amount of back and forth studies between real conditions and the theoretical part, but 'Theories 01' was mainly archival research and remote assessment. It's possible that there is some cultural bias and some outdated resources may have been used. Therefore, the investigation carried out within the real context is as essential as the pre-study of the relevant existing theories. It is believed here to be crucial to activate one's curiosity and attempt to perceive the realities of a particular topic through different perspectives.

The interviews, which started during the third week of the field research, were conducted in order to investigate the relationship between the actors from the four sectors and their interactive learning, as well as their familiarity with the multi-/ inter-/trans-/disciplinary approaches.

PRIMARY OBSERVATION
CASE STUDY : ACE-ESD CENTER

What is the ACE-ESD ?

The African Centre of Excellence in Energy for Sustainable Development (ACE-ESD) is located in the College of Science and Technology, in the campus of the University of Rwanda. The ACE-ESD is an organization established under the auspices of the World Bank's Eastern and Southern Africa Higher Education Centers of Excellence Project (ACE II) and supported by national governments within the region.

The center aims to implement and improve Interdisciplinary research, provide training in smart and micro-grid energy technologies and distribute the renewable energy, power systems, energy management and trade policy to remote and rural areas in Eastern and Southern African regions.

Who is part of the ACE-ESD ?

There are about 40 Ph.D. student researchers and 120 students at the Master of Science level, which is composed of three main programmes; renewable energy, power systems, and energy economics. The majority of the existing students, researchers, and instructors are experts in mechanical and electrical engineering. The center has tried to expand and include more experts from other fields. So the center invited a business and entrepreneurship instructor to transform the center into an incubator center. During the SIDA funded-partnership, the proposal for the incubation center is to scale it up to become a co-innovation hub to reach out more to the public and encourage diversity.

What kind of activities does the ACE-ESD host ?

The place is not fully occupied. There are working offices for the center's administrators, a classroom, a computer room, and a laboratory for the Master's programme daily events, such as lectures. The PhD student works separately, and they visit the center to meet with their supervisors, to attend presentations, and to contact the administrator. Additional activities are visiting and meeting professionals from other departments of the University of Rwanda and other institutes inside and outside of the country.

Figure 1.16. The front of the ACE-ESD Center building

Figure 1.17. The back of the ACE-ESD Center building

INTERVIEWS

What are the interviews about ?

As mentioned before, the interviews in this study are a way to understand the relationship between the different pillars of the Quadruple helix in Kigali, and analyze their culture of interactions as well as their familiarity with the cross-disciplinary approaches in working and learning environments. This interview focused on cross-learning cultures. Multicultural environments can contribute greatly in fostering transdisciplinary working and learning. The cross-learning cultures of the actors from the four sectors are composed of many different layers that can overlap with the ways and norms of different organizations. The way these overlaps occur depends on the discipline, the form of organization and the region that they're in.

The interview questions aimed to investigate three main points;
A. Inter-/trans-disciplinary experiences in the organization
B. Activities to support interactions in the organization
C. Bidirectional relationship with other organizations

Who took part in the interviews ?

There were three official interviews with people at ACE-ESD and one informal interview with a young entrepreneur;
- A Ph.D. researcher
- An Administrator, Electrical Engineering Profession
- An Instructor, Business and Entrepreneurship Profession
- And a manager of a social enterprise (Personal Communication)

Note: further information on the interviewees can be found in appendix A

Data Collection 01

Results of the primary observation. Revealing the challenges to reach Trans-disciplinarity.

RESULT OF THE INTERVIEW

A. Inter-/trans-disciplinary experiences between the different ACE-ESD divisions

Interdisciplinary approaches exist within the ACE-ESD but not transdisciplinary ones. The business sector is the only one that works directly with the users. The obstacles when working with the local community are the language barrier and the lack of interest from local people to participate in academic works.

B. Activities to support interactions between the different ACE-ESD divisions

The interactions at work take place as occasional formal meetings; conferences, public lectures, workshops. There seldom is anything more than formal events, since people tend to socialize more with friends and family that have no relation to their job rather than their co-workers. What also reinforces the lack of activities of various levels of formality, is the limitation of activities and potential target groups due to costs and different geographical location.

C. Bidirectional relationship with other organizations

There is little interest in forming (new) connections. The projects and events that are created, are mainly targeting already existing connections/partners and are carried out in a top-down way.

The interviews reveal the perspectives of the actors belonging to the academic helix, and of a few people that are related to the business helix. The result of the interviews disclosed the challenges in reaching a transdisciplinary approach. The interconnection between the actors from the four sectors is still fragmented and collaborative and creative activities are still rare within the organizations. What is needed is the forming of personal connections and the nurturing of a partnership relation between the different people involved if an interconnection between the actors is to be established.

CHALLENGES OF TRANSDISCIPLINARITY

MONODISCIPLINARY

There are two different layers that need to be addressed when it comes to challenges regarding monodisciplinarity in the context of this case study. An internal layer, within the existing programmes of the ACE-ESD, is that interactions happen only among people of higher education, i.e. master and doctoral students within the engineering disciplines, especially those who belong to Electrical and Mechanical Engineering. The question that arises is how can different students belonging to different levels of education (bachelor, master, Ph.D.) within a discipline be more tightly connected? This relationship could expand and include other fields of study and other faculties on the campus, such as the school of Architecture and the Built Environment. The College of Science and Technology, is an umbrella college that includes not only Electrical and Mechanical Engineering, but also other departments in between, where new connections could be formed, such as the school of Mining & Geology, and the School of Information and Communication Technology.

An layer external to the ACE-ESD and the college of Science and Technology, is the missing connections with other colleges on campus, for example the neighboring College of Business and Economics or those that are located in different parts of the city –or even the country- like the College of Education in Kigali. The university has a wide range of disciplines such as medicine, agriculture, art, and social science scattered around Rwanda's provinces. Therefore, the issue at hand is to find a way to open up the Colleges of Science and Technology and make room for interactions with other disciplines as well as the general public.

FRAGMENTATION

Since the campus site used to be a military camp in the past, when the University acquired the right to use the space, the different functions of the educational facilities had to be assigned to the already existing and available spaces that were certainly not planned to be used as such. New academic programmes and adjacent organizations had to also fit in any remaining unused spaces. And as for areas of culture and recreation, e.g. the cultural village and the public arts and crafts exhibition hall are located far from the university, without actually having any relation to the studies or activities that take place at the University. The external organizations that have a connection with the University Rwanda, for instance the "Association for Women in Science and Engineering", and several research partner institutes, are occupying some of the available rooms in the campus' buildings without having any connection to the public or to new visitors. The ACE-ESD is one of the organizations that received an existing building on the campus. The classrooms and administrative offices occupied the available space of the existing building, each in separate rooms, without any relationship between them.

It is an aim of the University and the ACE-ESD to shift the educational approach towards a more collaborative way of operating, but the spaces are still fragmented and isolated, resulting in disconnected activities.

SINGLE HELIX : ACADEMIA

The initial stakeholders of this project are representing two academic institutes: Chalmers University of Technology and the University of Rwanda. Despite their efforts to involve researchers and instructors from business and the entrepreneurial world, it still remains in the academic world - transdisciplinarity cannot happen limited to this context - not even interdisciplinarity - if the comprehensive innovation system does not include the other three sectors: Business, Public Sector, and Society.

What makes both the field research and the forming of connections between the sectors harder is a series of restraints ranging from physical distance between the different institutions and places of interest, to language, regulations and security. Any researcher that wants to pursue e.g. an interview with people outside his/her institute, has to hold a research license. Most places in Kigali have a strict security checkpoint, especially in public places and government organizations, including Universities. The visitor has to state the purpose of visiting and present his/her ID card to enter. In the local communities, the languages spoken are only Kinyarwanda and French.
Moreover, financial and social status are factors based on which people and their activities are segregated. While businesses and foreign individuals can easily, through their own budget/salary connect with and commute to different places. Students or people of low-income have great difficulty in traveling across the city as public transportation does not cover all areas and alternatives such as bike taxis are not an affordable option. These halt the possibility of exploring and connecting to people outside one's (academic) community. Adding to the aforementioned obstacles, even though there is sufficient funding and support from the organizations, the bureaucratic procedures of the system make processing documents or requests a highly time consuming task.

It therefore becomes a real challenge for a pilot project to create a comprehensive innovation system with four sectors, to pick the right stakeholders, engage people and maintain active participation.

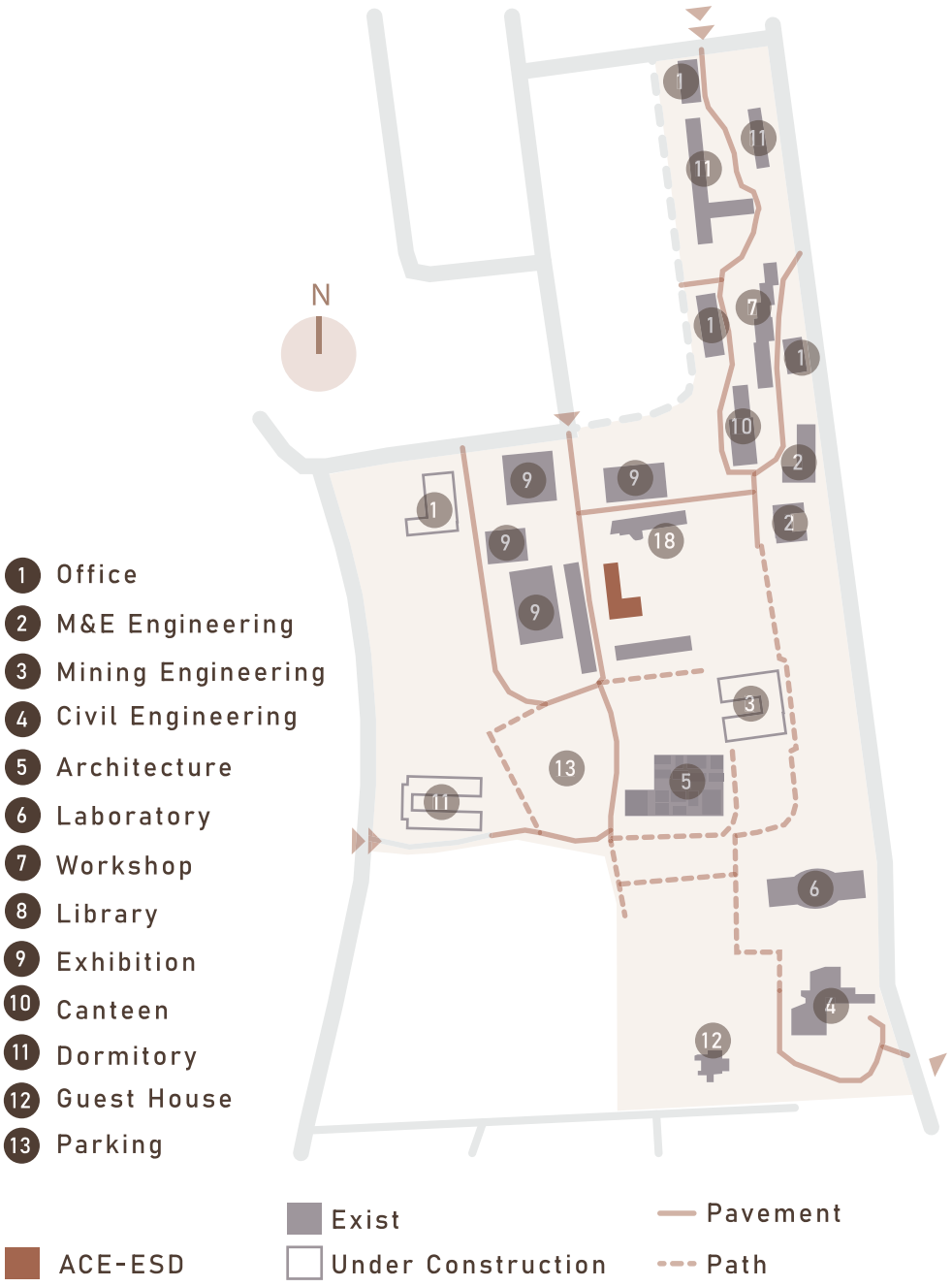


Figure 1.18. The map of Nyarugenge Campus.
The College of Science and Technology, the University of Rwanda

Phase 2 - Concept

Theories 02

A more detailed investigation, understanding the actual context by studying the historical evolution of Rwanda and participant observation (referring to actors from the sectors) in different communities in Kigali.

From phase 1 - The investigation conducted through the interviews and through the primary observation, revealed the existing challenges. This second phase is the participant observation that runs in parallel with the study of Rwandan history. The part of research that revolves around participant observation aims to study other actors outside of academia.

However, this project does not have access to actors covering the four sectors yet. One of the most obvious first results of this observation, was that the people and the cityscape of Kigali exhibit wide differences from one area to another. Nyamirambo, Kiyoyu, and Kaciru are three areas/hills that have very specific characteristics. Each area's architecture has a distinct style and their people respond to different kinds of business, the public sector, and society. The author was living in the Nyamirambo area for six and a half weeks, visited different companies and organizations, and was a customer of public facilities and social enterprises.

In addition, a study of Rwanda's history supports an in-depth familiarization with the more intangible parameters that shape the context, e.g. social movements and cultural norms in periods of time that influenced contemporary Rwanda.

PARTICIPANT OBSERVATION

The ambition of the public sectors after the genocide was to re-organize the cities' structures in order to eventually render them brighter, cleaner, and easier to manage. The administrative division and the classification of areas by hills however, has remained the same. These are the main areas of Kigali that are surrounded by small villages:

NYAMIRAMBO : Muslim, Residential and Commercial Area

- Mosques, affordable houses, shopfronts, local restaurants, and market

KIYOVU : Central Business District (CBD)

- Grocery stores, hotels, banks, airline offices, and cavernous malls

KIMIHURURA : City Hub Area

- Convention center, retail complex, embassies, offices, restaurants, and cafe

KACYIRU : Residential Area

- Mid-sized houses for young foreigners, restuarants, bars, cafes and gym

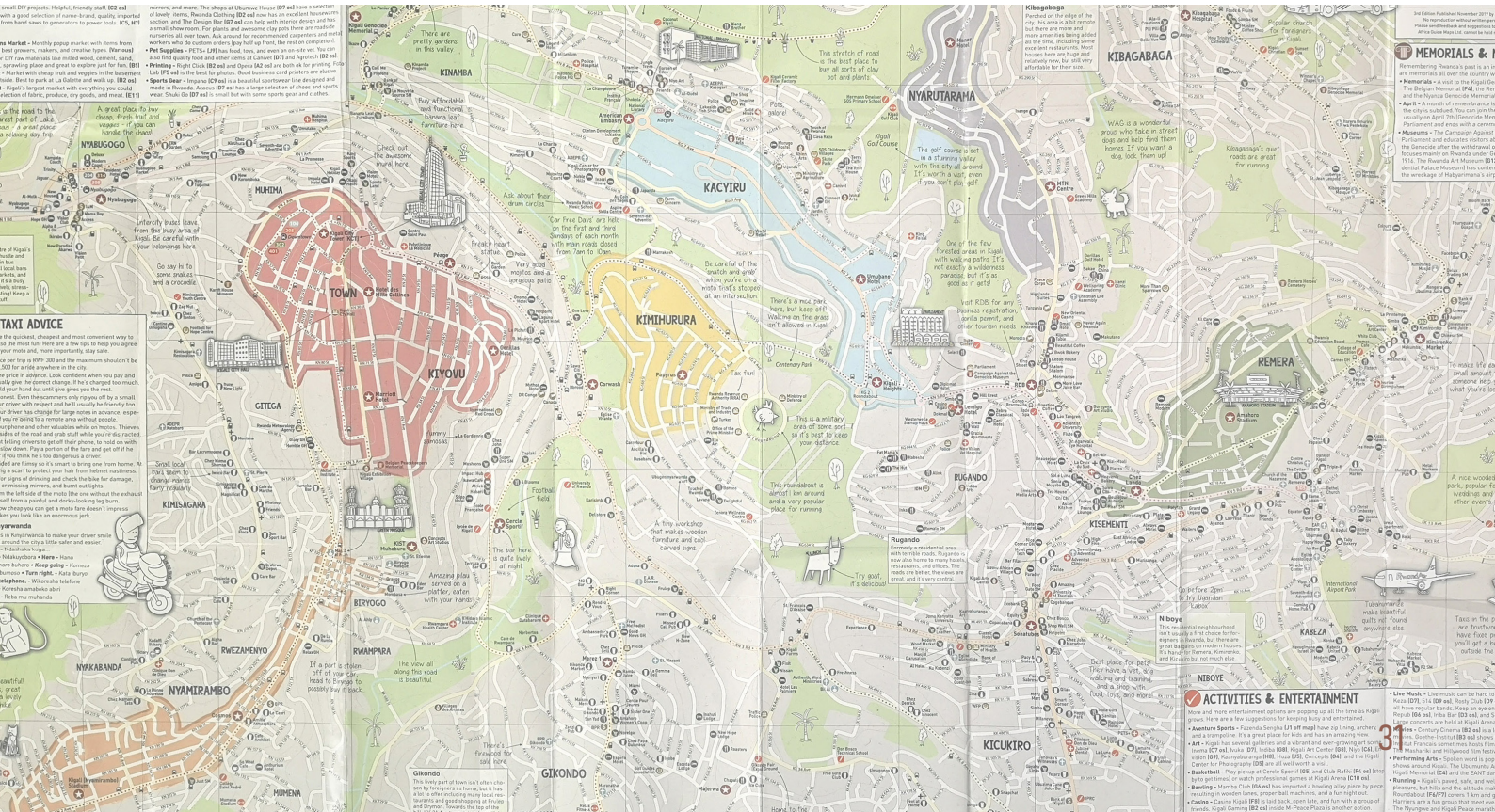
NYARUTARAMA : New Area

- Residents of embassies workers, cafes, restaurants, international companies

REMERA : Entertainment Area

- Local bars, clubs, the national stadium

Figure 2.1. The map of Kigali City from African Guide Map. (2019).



When passing through the hills of Kigali, one can feel and notice the traces of the rustic elements of the past that have survived the surging of the modern lifestyle. NYAMIRAMBO, KIYOYU, and KACHIRU are the three main areas where it's possible to notice the different characteristics of Kigali

NYAMIRAMBO AREA :

busy area with people gathering around the shops on the main streets and the small, local supermarkets. There are also affordable houses for local people and people who move in from other provinces.

Figure 2.2. Nyamirambo area

KIYOYU AREA :

this area can be called "downtown" which is also the name of the nearest bus stop that informs visitors where they are currently at. The central bus station is also located in this area. This means that Kiyoyu is the main transition point to other hills and other provinces outside Kigali. It's an area full of commercial buildings, wholesale markets, and national organizations, for instance the Kigali city hall, RwandaAir, the national bank of Rwanda, etc.

Figure 2.3. Kiyoyu area

KIMIHURURA AREA :

the area expanded into surrounding the Kigali Heights mall and the Kigali convention center. Most international organizations, NGOs, government offices, and embassies are located in this area, complemented with fusion cuisine restaurants, modern cafés, and a lot of other similar facilities.

Figure 2.4. Kimihurura area

The traces of colonialism are quite visible throughout the country and elements of that era were melted into the various Rwandan cultures. The main languages used nowadays are Kinyarwanda and French, Some church, residence, and government buildings before the genocide are still used, with new functions.

After the genocide in 1994, the country has been trying to rebuild and repair its socio-economic structure. Nowadays, Rwanda is one of the countries in Africa growing very fast, and technology has been a key tool in alleviating the harsh socio-economic conditions while having great results in increasing the country's growth rate (Voluntary national reviews database, 2019). The public institutions are conducting investigations on new technologies and innovations into civil society, with the help of academic institutions focusing on technological innovation.

As international influence flows in Rwanda, investment on and through public institutions started slowing down in 2016-2017. The private sector is gradually taking the lead in maintaining Rwanda's growth (Worldbank,2020). Many European, American, Chinese, Japanese, and Korean companies as well as international NGOs, are investing in and running the Rwandan economy, and are located mostly in Kigali. This shift is inscribed on the city's urban fabric. The places are constructed to accommodate foreign administrations, for example, housings and high-rise office buildings, creating a sense of place that ostentatiously showcase a wealth of architecture contrasting to the context. International products and services are steadily popping up around the city, while technological investments are increasing.

On the other hand, the city's outskirts are still home to manual labor; From agricultural workers and farmers, to craftsmen and cleaners, many of these people do not even have access to public services and education. These areas attract NGO investment and research, for instance on off-grid energy systems and clean water systems. Apart from those, socially-oriented organisations are trying to provide English and computer classes, as well as professional training in e.g. handcrafting and sewing at Nyamirambo Women's Centers or coffee farming and bartending at "Question Coffee". At the latter they can either work for the shop after the training is completed, or start their own business. The organizations are also promoting the creation of a workshop for visitors, aiming to increase community participation and attract agricultural tourists.

Prediction 02

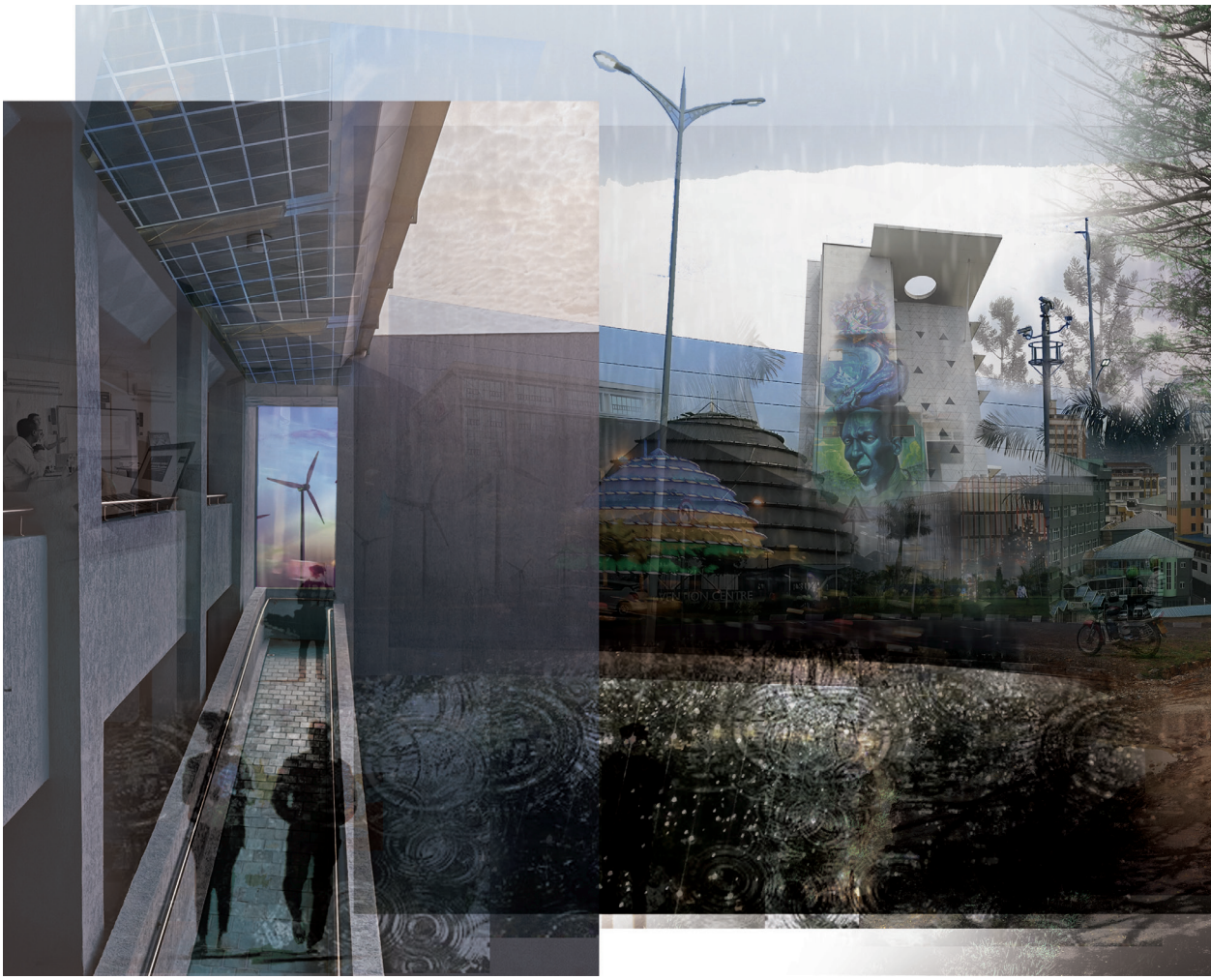
An insight on the characteristics of the context that will guide and develop the design approach. The concept of 'Contradictions' shows the difference between local and international communities, but also the similarity in their view of natural resources as a shared value.

Within the premises of the theoretical study, all sectors of actors have emerged as equal without any distinct hierarchy within the quadruple helix model. In reality, some actors are/should be prioritized more. Regarding this particular case study, located in the context of a developing country that has a weak economy, the value of nature and tradition would easily give way to the "higher", monetary values of overseas investors. The private sector, the international organizations, and the government are dominant powers. They greatly influence decision making and co-learning. Any real result from the testing of this thesis's hypothesis would perhaps be biased towards those dominant powers. The interactions are at risk of being a one-way relationship, and the actor who is prioritized the most is the authoritative figure.

As more challenges emerge when taking into account the hierarchical relations, the concept of 'Contradictions' is emphasized to illustrate these challenges in the design approach. There are a lot of contrasts to be found when analyzing the different parts of the context in detail, but the distinct differences between the international and the local community are the most prevalent. This identification is not to reinforce segregation but to attempt to discover what will bridge the gap created due to monodisciplinarity and fragmentation. The differences reflect their behavioral patterns and the requirements to attract other types of sectors, from all learning levels and with a variety of interests. Additionally, the intention is to increase the importance of all agents through their different capabilities, excluding the financial capability.

Moreover, the similarities spotted among all the differences also highlighted what type of connection is needed to encourage an interaction that transcends common objectives such as co-learning and collaborative activities and becomes anchored in shared values. Nature and natural resources, for example, are a shared element, appreciated by all actors that are also connected to the general theme of energy innovation.

THE CONTRADICTIONS



As shown in the figure 2.5. there are differences between the local and the international communities, as depicted through spatial characteristics, as well as the presence or absence of cutting edge technology. These contradictions are shaping contemporary Rwanda, and the different nodes are interconnected. In reality, everything is interconnected, but it is hard for people who are part of the context to identify the connected paths and find their nodes.

A contradiction can often imply a division between positive and negative aspects. In this case, the contradictions signify two different values. These values have been co-existing and are what helps the city grow into the unique mosaic that it is.

Figure 2.5. The image of the Contradictions concept

COEXISTENCE OF THE CONTRADICTIONS

NATURAL RESOURCES

Figure 2.6. The Natural Resources in the Contradictions concept

As mentioned above, a shared interest among all the different sectors could be the country's natural resources. Since the case study falls within the theme of energy, natural resources are the reference point for all disciplines within the academic sector, as well as for the rest of the sectors including society. The scientific groups attempt to develop renewable energy through academic research and infrastructure through technological innovation. People, on the other hand, are relating to natural resources in their own way; in rural communities, people support their lives by self-generated electricity, water/ hydraulic systems, and food and all that is produced with traditional and simultaneously affordable methods.

INTERNATIONAL COMMUNITY AND LOCAL COMMUNITY

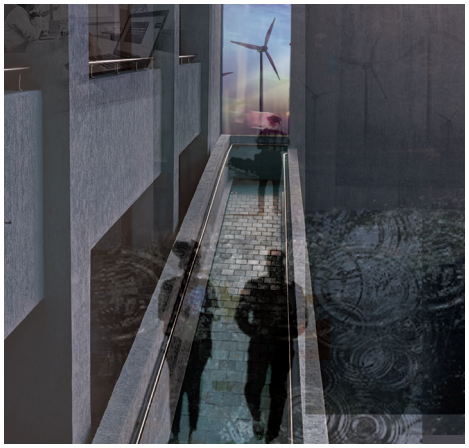


Figure 2.7. International Community in the Contradictions concept

Figure 2.8. Local Community in the Contradictions concept

Through the contradictions in activities, spatial characteristics, interests, and investments, the communities living in Kigali can be categorized based on local ancestry; there is therefore an "international" community and a form of "local" community.

Reality 02

This phase, i.e. the investigation on the design approach was included in the presentations and discussions with the Co-Design team and Stakeholders, the ACE-ESD team, and the University of Rwanda's representative committee.

The concept of 'Contradictions' is one of the main approaches to the project. There are three more concept ideas developed within the co-design team. The team has met and worked together since the beginning of the in situ investigation in Kigali, at the time when the "Reality 01" phase took place. The workshops conducted helped the team by making each member's role clear, by revealing the strength in each thesis project and also by connecting points between the different design concepts and the theoretical design approach.

After six weeks of research on the field, a meeting with the ACE-ESD team took place. The co-design team also presented our collaborative progress and individual concepts.

CO-DESIGN TEAM

Due to both universities having different schedules, our processes were not in the same stage. As part of the experiment with the collaborative process across disciplines, two workshops for group dynamics and shared vision were created. Even though each participant belongs to the same discipline, we all come from different cultures. We shared our perspectives, expectations, and project considerations with each other. They explained their site analysis and design concepts, and the author shared her theoretical studies. Some results were common, but achieved through different approaches. Our agreement was to work collaboratively. Even though our individual thesis projects are going to be implemented in some way, it is better to be thoughtful and collect ideas. Therefore, we met weekly to update and provide feedback to each other.

Figure 2.9. Co-Design Team

CO-DESIGN PROCESS AND THESES PROCESS

Figure 2.10. The process of Co-Design and theses

SHARED PROJECT CONSIDERATION

Thesis Focus

Bachelor Thesis is focused on
Design in terms of functions, forms and architectural elements

Master Thesis is focused on
Design Approach in terms of co-design process and design strategies

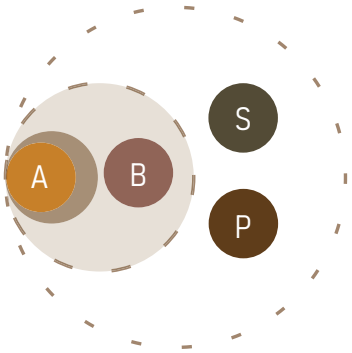
Intension and Goals

Job Opportunities >> Economic growth, Zero hunger and poverty, and Sustainable Energy

Transdisciplinarity >> Innovative Solutions for Complex Challenges by National Development Agenda 2050

Variety of Users

Considered as Academia is going to be a majority of the user, the business also has potential. The engagement of public sectors and society is slightly found, they should be more involved.



SHARED CONCEPTS

Create Space for Creativity

Collaboration, Variety of users

Better Quality of Space

Concept :

Social Interaction
by Mathias Uwamahoro

Nature Connection
by Boniface Tuyisenge

High-Technology and Design Elements
by Sylvie Dufitimana

Promote Interdisciplinarity and Transdisciplinarity through spatial design process

Create bidirectional learning and relationship between four sectors of actors within innovation space

Concept :

The Contradictions
by Pattaraporn Thumjunjua

THE ACE-ESD TEAM AND THE UNIVERSITY OF RWANDA COMMITTEE

The team of researchers from the University of Rwanda and Chalmers University of Technology presented other case studies of innovation hubs in East Africa. They also presented their collaborations with other actors, especially with entrepreneurs. Following that, the co-design team presented their collaborative process, their individual theses, and their design concepts. Fortunately, the case studies that the researchers presented supported the core hypothesis of this master thesis that the involvement of the other three sectors is significant to advance innovation systems successfully. At the end of the meeting, they reached the positive decision to scale up the project for creating a collaborative innovation hub.

The majority of stakeholders and the committee have a background in engineering. It is therefore crucial that the architectural presentation should be illustrated in such a way that it can be understood by other fields. The conceptual phase is the most susceptible to misinterpretation by the audience. As the coordinator of the co-design team, the author has tried to come up with a clear presentation structure illustrating a direct message that focuses less on the details architects normally focus on, in order to get the message across to everyone in the audience.

Figure 2.11.1. The presentation of the ACEESD Team and the UR Committee from 2020, March 17.

Figure 2.11.2. The presentation of the ACEESD Team and the UR Committee from 2020, March 17.

Figure 2.12. The presentation of the Co-design team process from 2020, March 16-17.

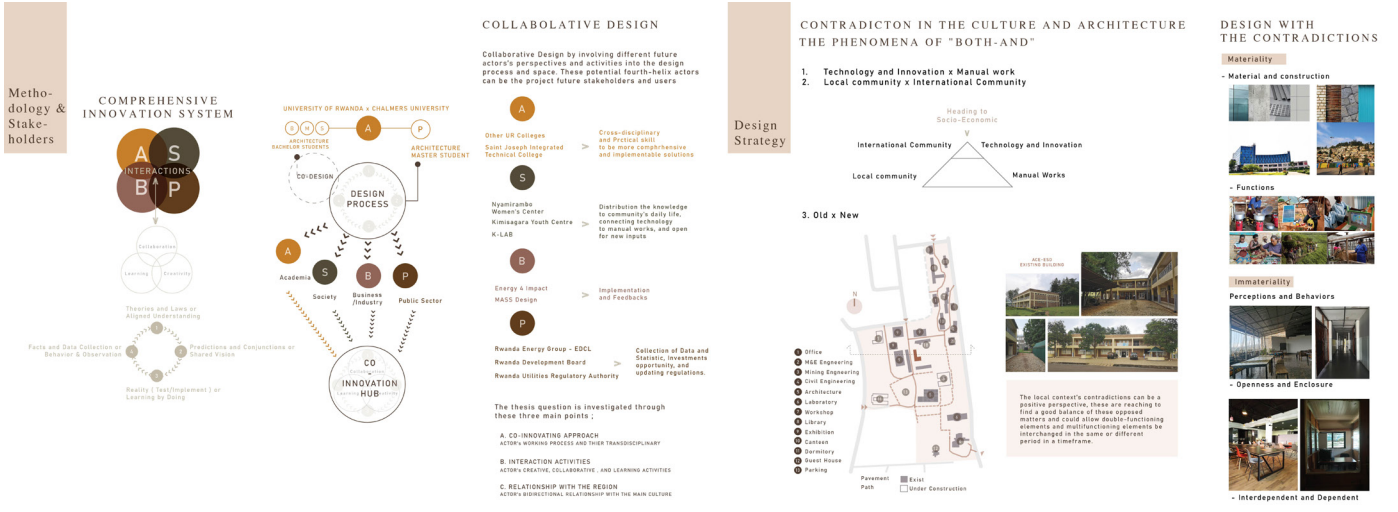


Figure 2.13. The presentation of the master thesis concept from 2020, March 16-17

Data Collection 02

This phase is the result of the presentations and discussions with the co-design team and the stakeholders, the ACE-ESD team, and the University of Rwanda's representative committee. It also includes the hypotheses on the four sectors of actors throughout the entire period of the field research.

Unfortunately, the research on the field was halted abruptly due to the global covid-19 pandemic and so the co-design team's process was paused. The previous plan for 'Combined functions & Designs' could not go forward. Nevertheless, parts of the ideas and concepts produced by the co-design team were taken into consideration. For example, the need to enhance job opportunities, to attract a variety of users with different (educational) backgrounds, or to improve the quality of a creative and collaborative space through social interaction, shared values and high-tech elements. The concepts developed within the co-design team were aligned with this thesis's theoretical anchoring, but there was never something more concrete than fragmented ideas until the workshops and following discussions.

Even though the design concepts were not finalized, the collaborative process and the different ideas were presented to the stakeholders, i.e. the ACE-ESD team. The first presentation brought up a discussion on the collaborative design and opened up another opportunity for the second presentation to the University of Rwanda's representative committee. The holistic vision of the project that was presented there, highlighted the need for scaling the Innovation hub project up and pursue collaboration with organizations and individuals beyond academia. The representative committee decided to offer one more existing building to the innovation hub project.

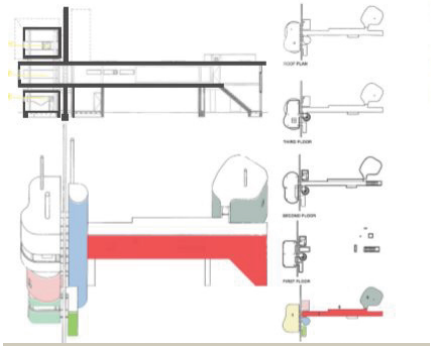
Under the global pandemic it was difficult to identify specific stakeholders to fit the quadruple helix model, except for those within the academic sector. There are, however, proposal and hypotheses on potential stakeholders after relevant research and studies.

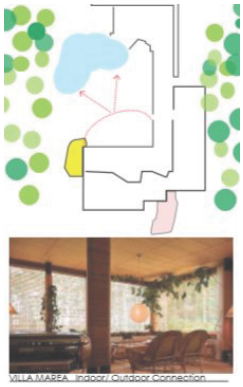
THE OTHER CONCEPTS DEVELOPED BY THE CO-DESIGN TEAM

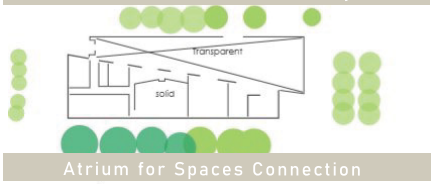
BACHELOR THESES

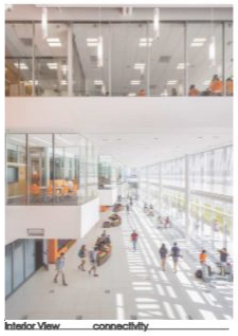
These are the three concepts to create space for creativity collaboration, variety of users better quality of space

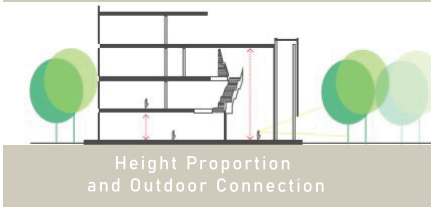
Social Interaction
by Mathias Uwamahoro



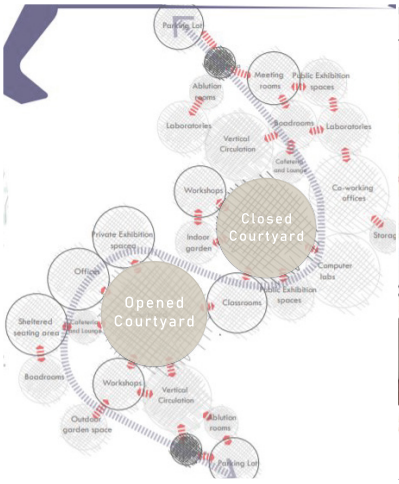


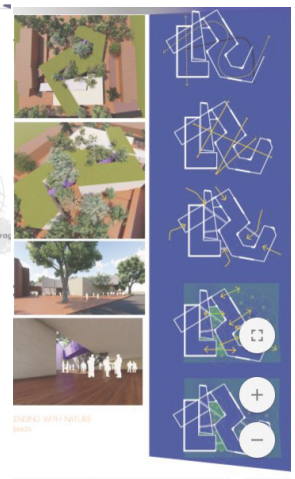






Nature Connection
by Boniface Tuyisenge





High-Technology Elements
by Sylvie Dufitimana

shading pattern facade for north and south

vertical automatic lovers for east and west facade

Shell with Solar Panels and Climbing plants for regulating the comfort

Figure 2.15. The concept of the bachelor theses by Uwamahoro, M., Tuyisenge, B., and Dufitimana S. (2020).

EXTENDING THE PROJECT SITE

The existing building, newly-added to the project, is the one next to the building which the ACE-ESD occupies and the plan is to transform it into the ACE-ESD Innovation hub. It was serving as a classroom building for one of the faculties. After the university rearranged the campus, the building was not frequently or officially occupied, but it was rather randomly used as extra classroom space when needed. From an architectural point of view, the inclusion of this building is advantageous to the flow of movement and to the hub's position as a complex within the campus.

Figure 2.16. The map of the extending building

THE HYPOTHESIS OF SECTORS OF THE QUADRUPLE HELIX

As mentioned previously, the connection between academia and the other sectors is loose, especially when it comes to the society sector. A small link to the business sector is already in place, but the actors belonging to this one have not met, shared, and learned in the same space before.

Regarding the various types of investigations conducted so far (i.e. interview, primary observation, participant observation, and discussion with the stakeholders), the project is on a very early stage, and actual future stakeholders could not be identified at this time. But there is a lists of potential actors, which formulate the hypothesis on the quadruple helix model. This hypothesis will be analyzed on the following diagrams.

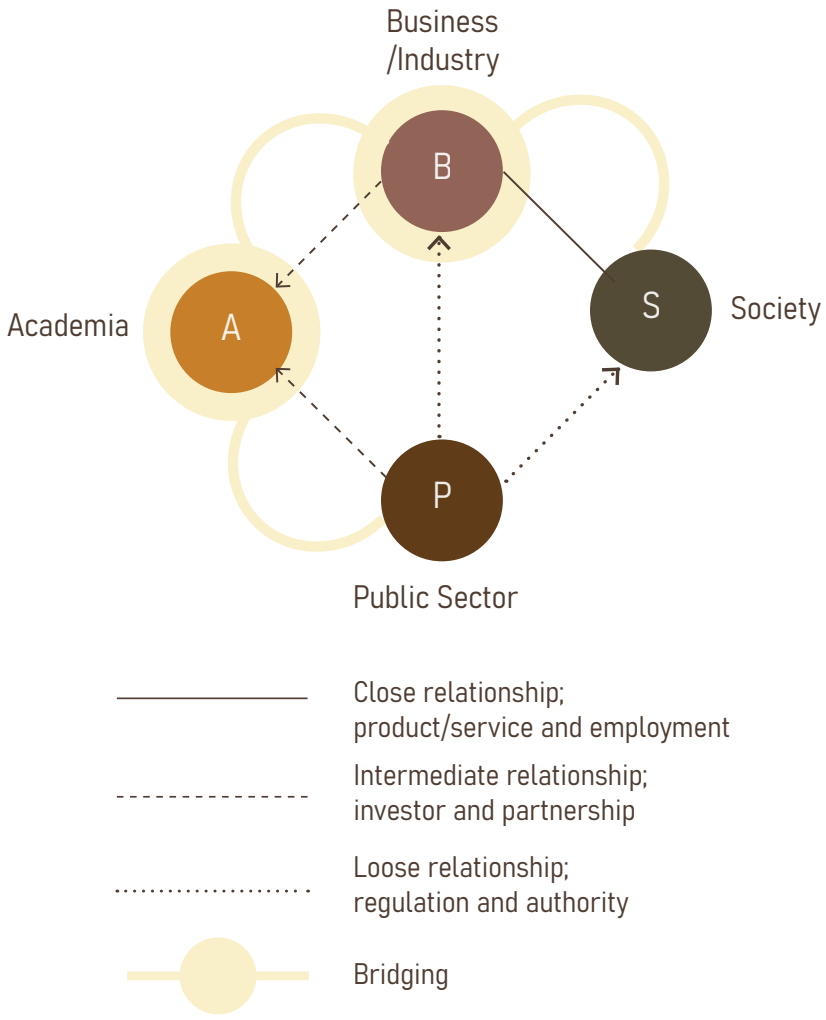


Figure 2.17. The relationship diagram of the four sectors of actors in the quadruple helix model.

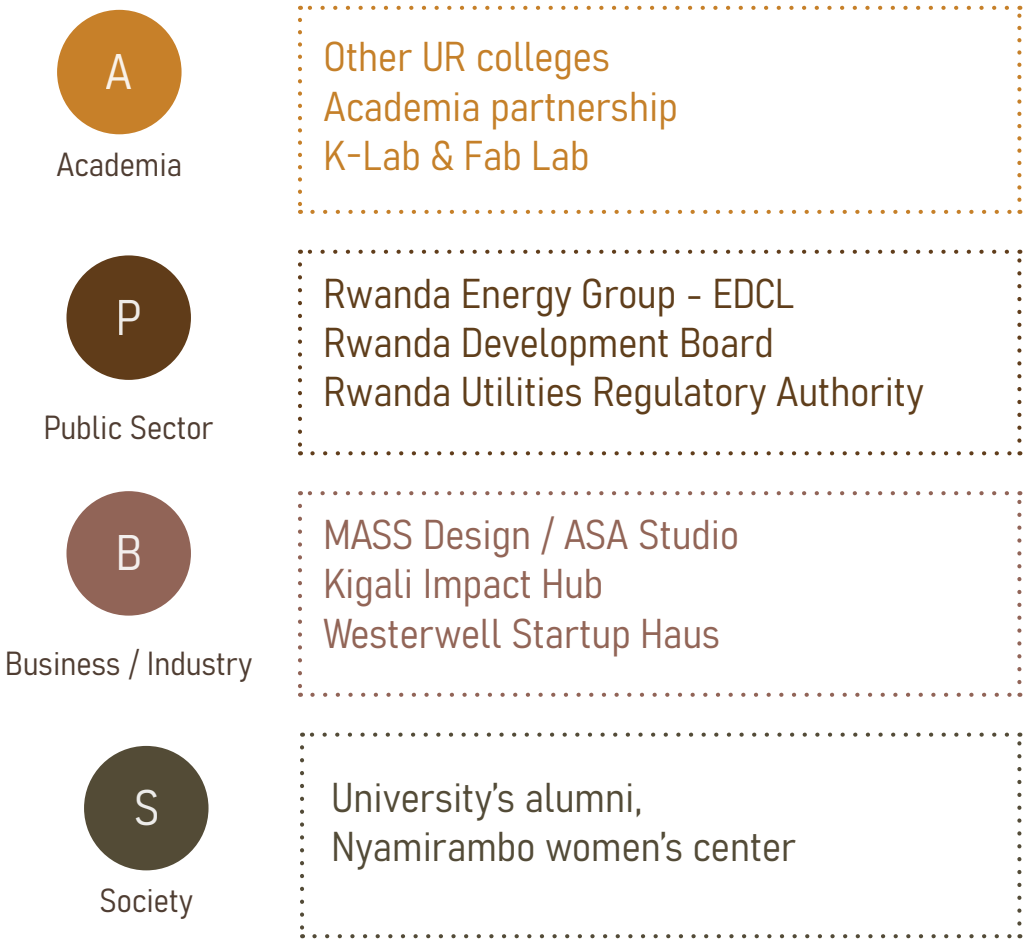


Figure 2.18. The hypothesis of the four-helix actors

Phase 3 - Design

Theories 03

Development of the design concept. The concept of “contradictions” reached the form of a duality. The duality is materiality and immateriality and based on this, the project will develop accordingly.

The contradiction, as a core design concept was developed through the "Complexity and Contradiction in Architecture" (1966) by Robert Venturi.

> "[...] Then equilibrium must be created out of opposites. Such inner peace as men gain must represent a tension among contradictions and uncertainties. [...] A feeling for paradox allows seemingly dissimilar things to exist side by side, their very incongruity suggesting a kind of truth".

This phrase illustrates what duality means in this context. The duality can be an ambiguity that bears several meanings and a variety of values. These inspired a design approach that aims to encourage the values of difference. The notions of a local and an international community as key players, of the natural resources as a shared value, all went through the "funnel" of duality.

The architectural design in general also has an inbuilt duality; it is essentially a balancing of materiality and immateriality. The Material aspect is easily pinpointed through the actual materials. Immateriality is invisible, but it influences architectural perceptions and operations. Immateriality can refer to the feelings a certain space provokes, or the different uses that it can host. The concept developed from that of the contradictions includes the notion of duality.

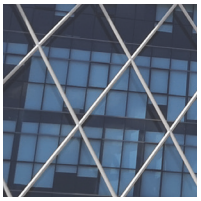
INTERNATIONAL AND LOCAL COMMUNITIES

MATERIALITY :


Brick


Wicker


Fabric


Glass


Aluminum


Metal sheet

INDUSTRIAL & VERNACULAR

The two communities have been living within an ecosystem composed of industrial and vernacular elements. The industrial materials are widely used in the local community as an expression of modernity, while the vernacular materials are an expression of the genius loci for the international community.

Figure 3.1. Images of the Industrial and Vernacular Materials from Kigali City in Rwanda

IMMATERIALITY :


Meeting Space, from Westerwelle. (2018).


Buffer Space

MEETING & BUFFER

Different working cultures across the globe, share the need for meeting spaces. But in this specific context, security and hierarchy are important elements to inscribe on the design of a space, therefore buffer zones are also needed

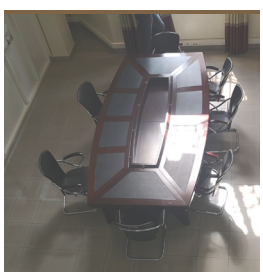

Shared Desk from Waka Work. (2020).


Own Desk

SHARED & OWN

Shared desks are generally frequently used in many organizations, but private offices are also widely used in this context.


Informal seminar space from Impact Hub. (2018).


Formal seminar space

INFORMAL & FORMAL

In a society with a more horizontal structure, working and meeting can occur in any place, even in a cafe or during a promenade. But within a hierarchical organization, the proper or official place is necessary in order to show respect to participants who have higher positions.

Figure 3.2. Images of working and learning spaces from Kigali City in Rwanda

NATURAL RESOURCES

MATERIALITY :

Figure 3.3. Images of technological and traditinal tools from Kigali City in Rwanda

TECHNICAL & TRADITIONAL

When sharing resources, people often have different preferences in which tools or methods to use, depending on their skills as well as the tasks ahead. Technological and traditional tools and methods both bear equal significance, since Rwanda is a country that has a technology-oriented strategy, but a rich tradition in craftsmanship.

IMMATERIALITY :

Figure 3.4. Images of renewable energy generation and natural sensory from Kigali City in Rwanda

USABLE & SENSIBLE

The common resources are ordinary and invisible in everyday life, but they are of utmost importance for any human-made space. These resources can, however, be perceived indirectly through the results of their operation.

Prediction 03

This phase is interpreting the information gathered to a design. The theoretical studies and the concept is guiding the zoning and the design elements to be employed.

The theoretical and contextual information, are interpreted in zonings and design elements. The theories are fundamental for the placement of the zonings and for the advancement of an architectural design that incorporates the notion of the duality in the contradictions concept.

The Quadruple helix model is referring to the four parts for the four main areas: Academia, Business, Public sector, and Society. The zoning is placed on the site in a way that renders the building accessible for the actors, while the central space contributes to their connectivity and to the distribution of movement. Additionally, each part combines all three forms of interactive space differently to support their own activities. Moreover, the circular processes facilitate the flow between a data-oriented process and a human-based process. Academia and Public sector work on the data-oriented side. Business and Society work on the human-based side. The central space also makes the flow between functions seamless.

The duality of the contradiction also manifests itself in the form of architectural elements and spaces that can balance the difference of local and international styles, and also emphasize the connection to natural resources.

SPACE OF THE QUARDUPLE HELIX

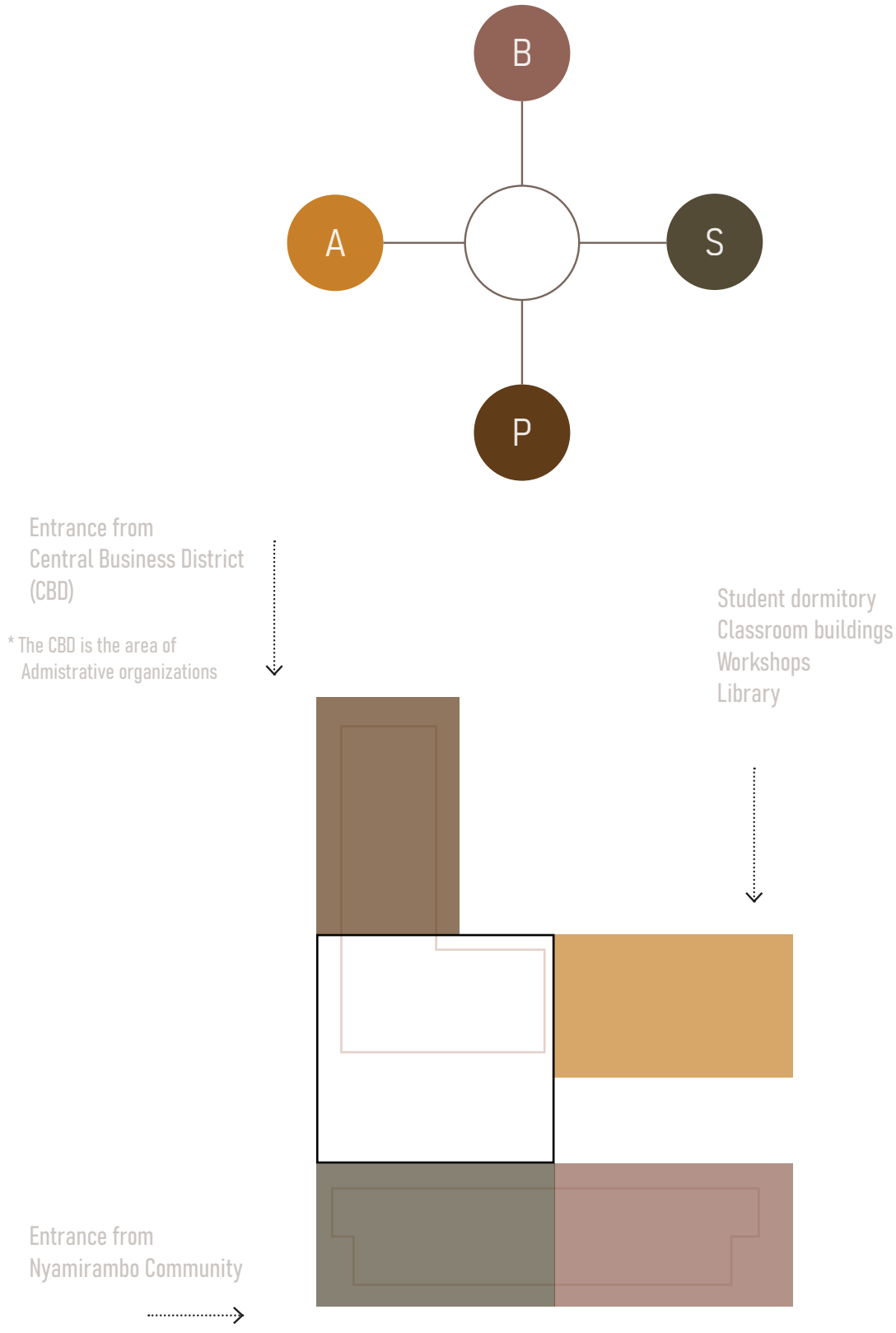


Figure 3.5. Diagram of the Quadruple Helix in relation to the proposed spatial organisation.

SPACES FOR THE THREE FORMS OF INTERACTION

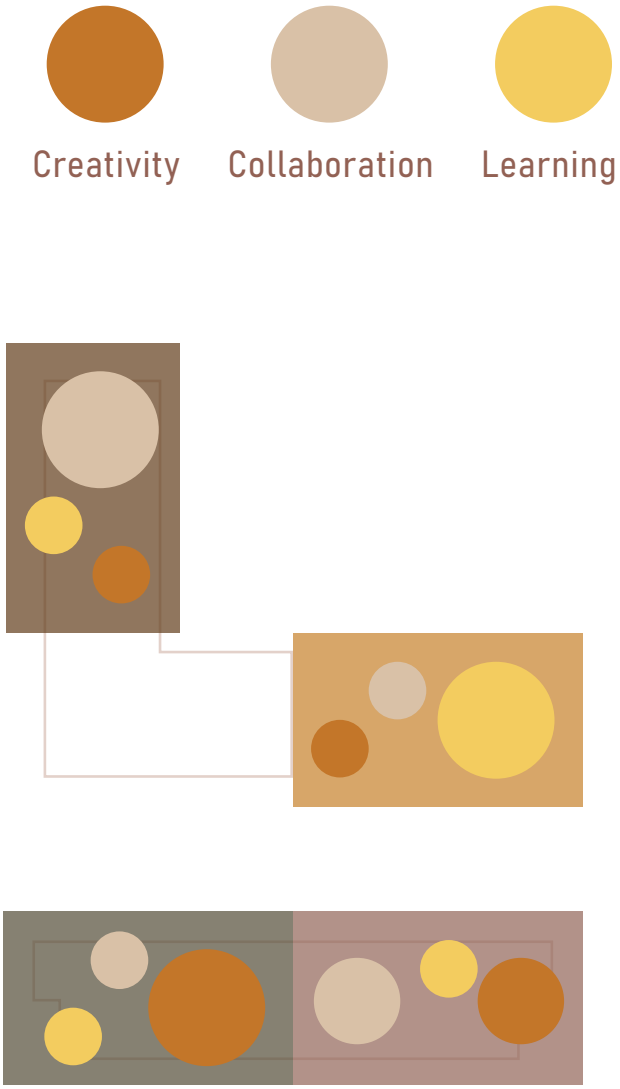


Figure 3.6. Diagram of the three forms of interaction in relation to the proposed spatial configuration of the Quadruple Helix model.

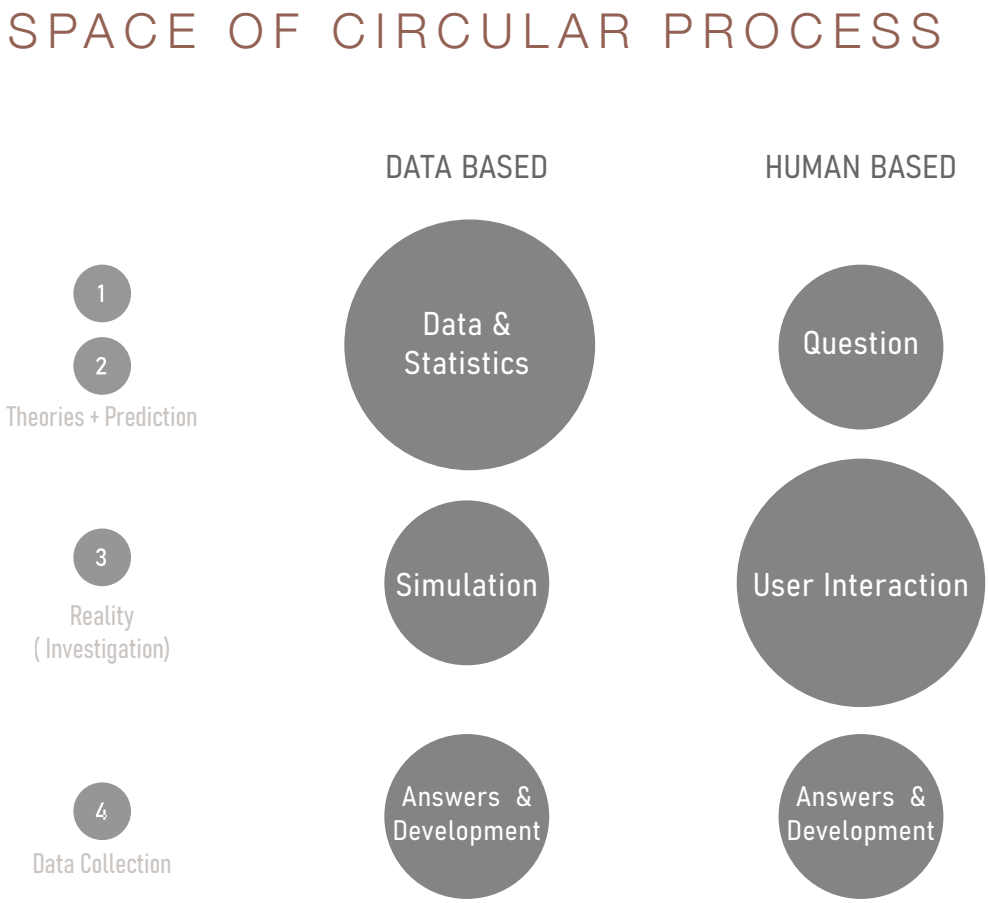


Figure 3.7. Diagram of the circular process by two different approaches

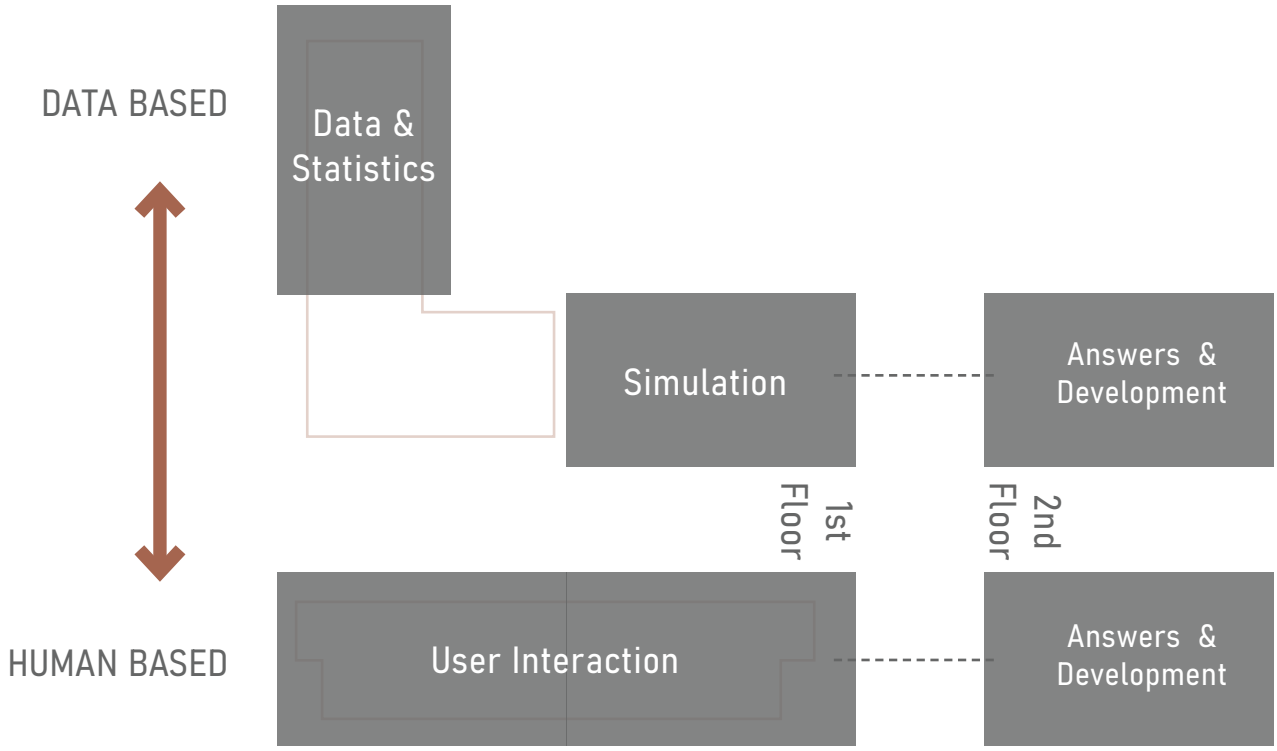


Figure 3.8. Diagram of the circular process within the proposed spatial configuration.

ELEMENTS OF INTERNATIONAL AND LOCAL COMMUNITIES

MATERIALITY :

Through the duality of the contradictions, these two different styles, the international and the local, are merged. The industrial and vernacular elements are designed to be flexible, adaptable and interchangeable. The parts of the building shell and the walls can be fixed at a later time, when circumstances and budget allow such endeavors.

INDUSTRIAL(INTERNATIONAL) & VERNACULAR(LOCAL)

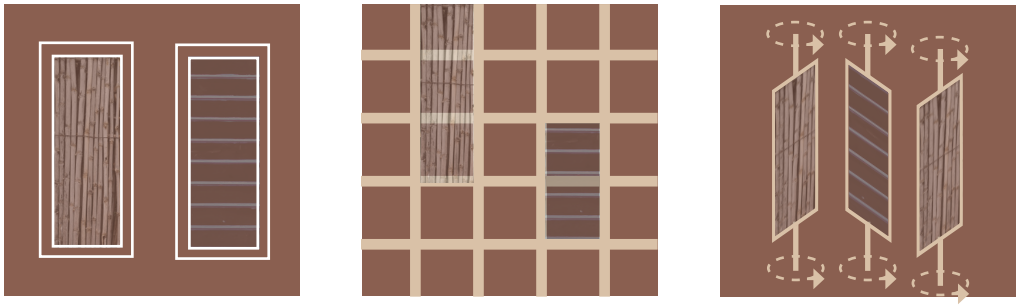
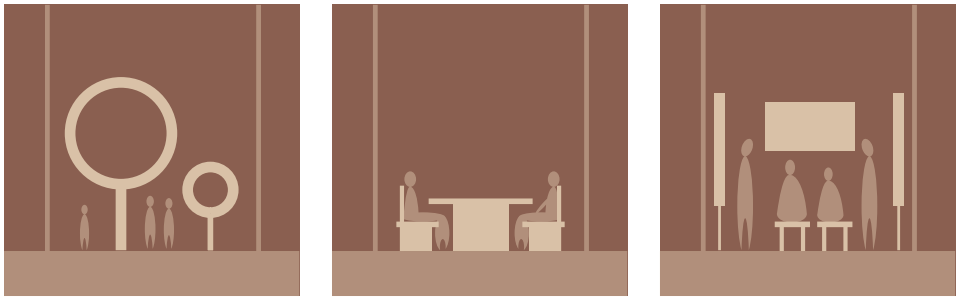


Figure 3.9. Illustration of industrial and vernacular elements in the design

IMMATERIALITY :

The typologies of space create duality as a spatial quality in order to support both international and local working behaviors. Green elements, food & drinks, and showcases are examples of spaces that can pose as buffer zones between the main functions of the quadruple helix spaces. Partial boundaries and flexible partitions can change the space from the duality of a shared space to the ambience of a space occupied by a specific group. The lecture and entertainment space are there to facilitate both informal and formal events.

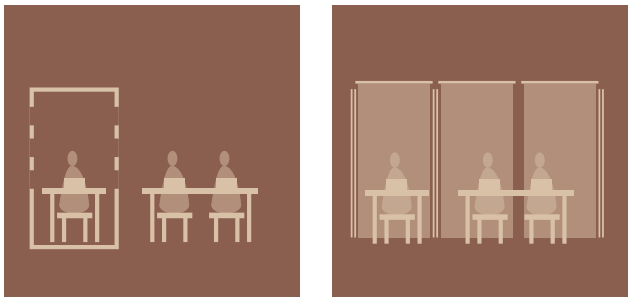
MEETING & BUFFER



GREEN FOOD & DRINKS SHOWCASE

Figure 3.10. Illustration of meeting and buffer space in the design

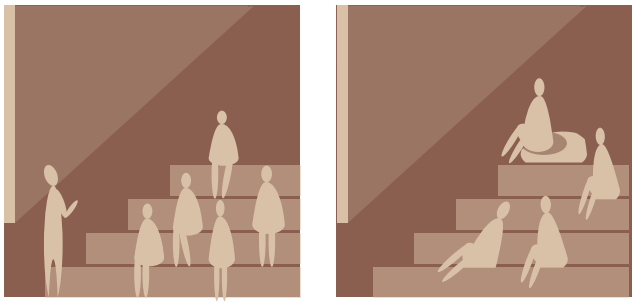
SHARED & OWN



PARTIAL BOUNDARY FLEXIBLE PARTITIONS

Figure 3.11. Illustration of shared and own space in the design

FORMAL & INFORMAL :



LECTURE ENTERTAIN

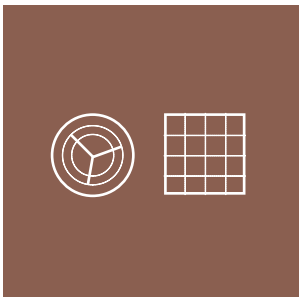
Figure 3.12. Illustration of formal and informal space in the design

ELEMENTS OF NATURAL RESOURCES

MATERIALITY :

Natural resources are a shared value, and they can be developed with cutting edge technologies or simple techniques to facilitate a variety of architectural functions.

TECHNICAL AND TRADITIONAL



WIND TURBINE &
SOLAR CELLS

BIOMASS

Figure 3.13. Illustration of technical and traditional elements in the design

IMMATERIALITY :

The natural resources are invisible but usable and sensible. They can turn water and energy to stimulants for the different human senses.

USABLE AND SENSIBLE

WATER & ENERGY
SUPPLY

NATURAL
ELEMENTS

Figure 3.14. Illustration of usable and sensible elements in the design

Reality 03

This phase is about the development of the architectural design proposal through the implementation of the design elements on the case study's existing structures.

This is the study phase that applies the zoning and design elements to the site in question. As mentioned in the first phase, the ACE-ESD is occupying the building in the Nyarugenge campus which served as a military camp before becoming (part of) an educational institution, and it is perceived as historical architecture. The new design maintains the original building structure and appearance as much as possible.

The following illustrations are explanations of the design depicting the combination of design elements layer by layer. The layout and master plan shows the overview and the placement of the four parts along with the central space. The three forms of interactions are indicated by the arrangement of the floor plans, and the circular process is represented through the circulation scheme. The duality elements are highlighted in the sections and perspective images.

LAYOUT AND MASTER PLAN

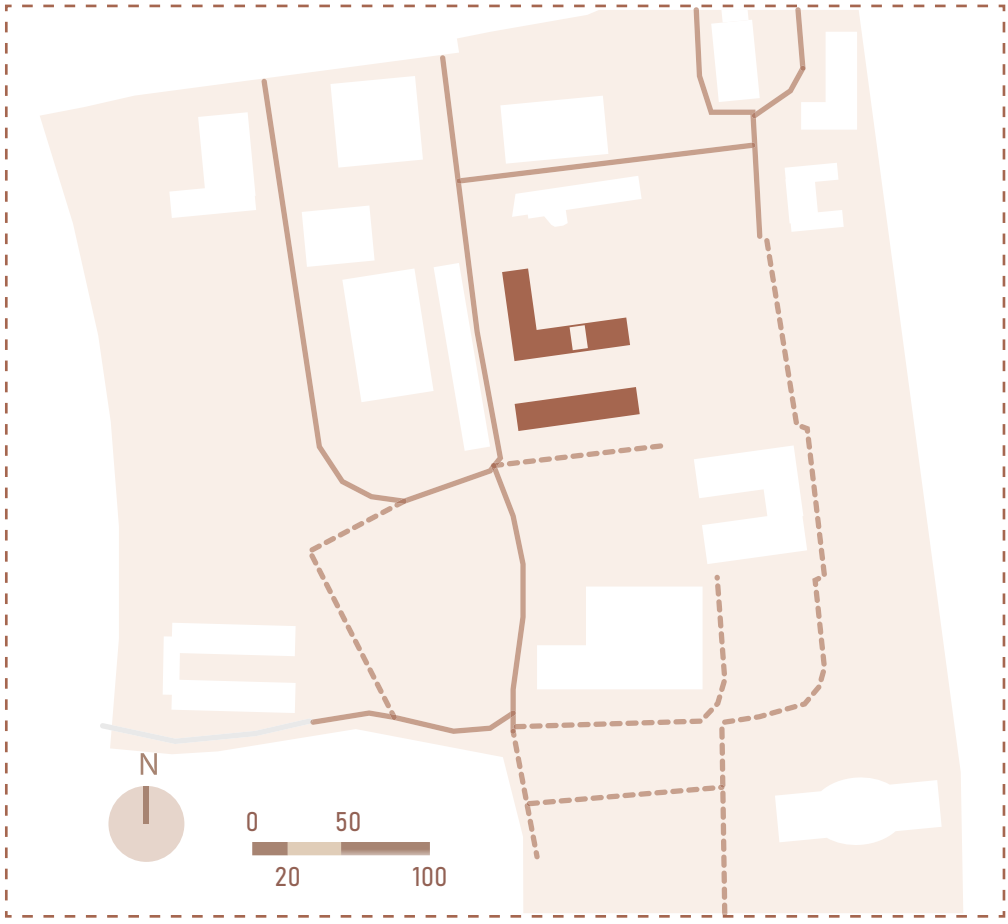


Figure 3.15. Layout of the design proposal

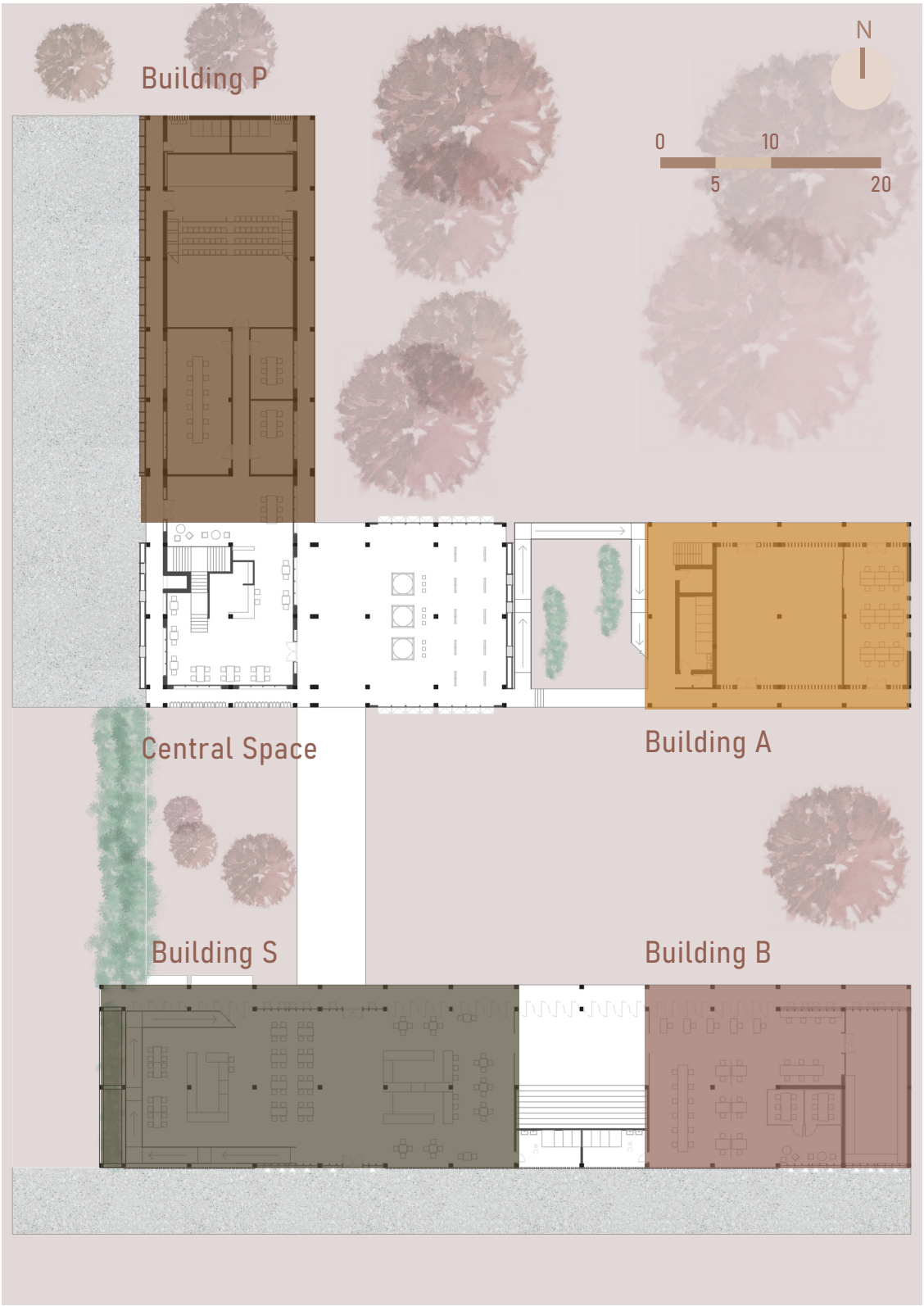
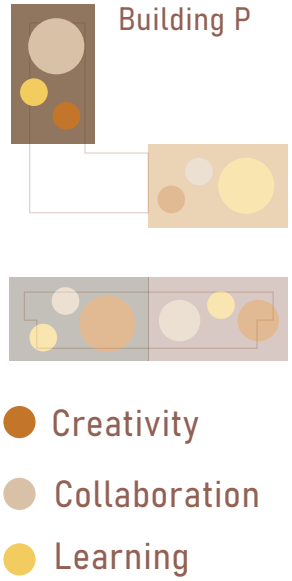


Figure 3.16. Master plan of the design proposal

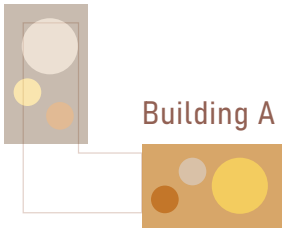
FLOOR PLANS AND ZONING

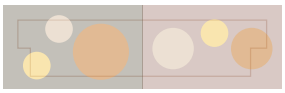


BUILDING P

The first main Building -or Building P- aims to support the Public sector, and the functions that allow cooperation to occur through formal events with other three sectors. The primary interaction is in the form of 'Collaboration', which translates to conferences and meetings. 'Creativity' is a supporting feature that is activated through recreational activities, and 'Learning' occurs through occasional events. The creative space and learning space are shared within the Academic Building -or Building A-connected through the Central Space.

Figure 3.16. First floor plan of Building P, Central space, and Building A.





- Creativity
- Collaboration
- Learning

BUILDING A

Building A is a proposed addition to the existing structure that focuses on the Academia sector. It is located in the inner part of the site. There is a deliberate retreat from the main road in order to secure a quiet environment for the classes and to be easily accessible by the users of neighboring campus buildings. Even though 'Learning' is the main form of interaction in this building, 'Creativity' and 'Collaboration' remain prevalent in the arrangement of functions through recreational spaces and meeting corners.

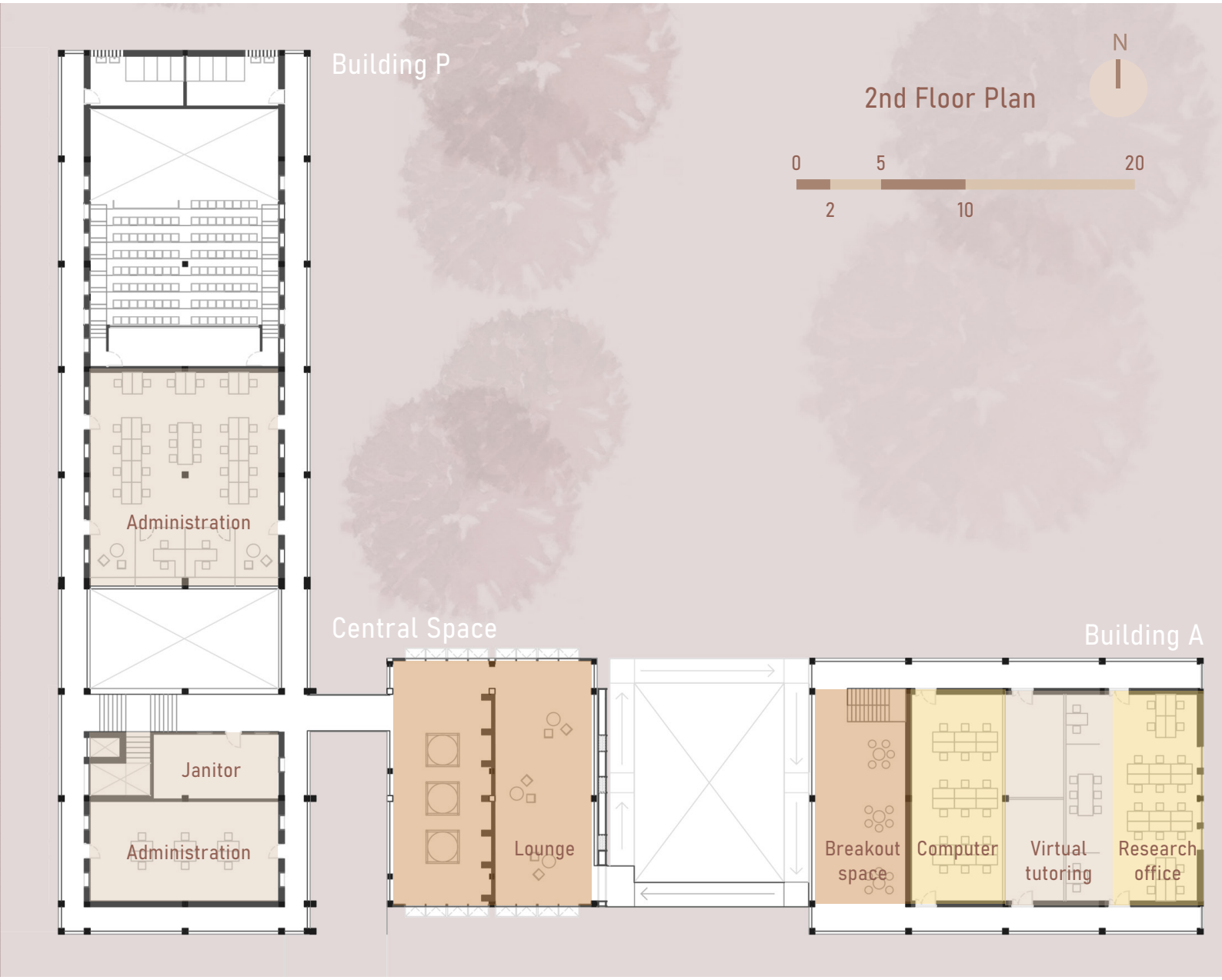
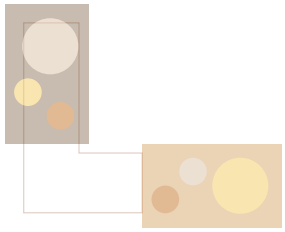
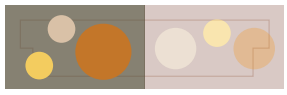


Figure 3.17. Second floor plan of Building P, Central space, and Building A.



Building S



Creativity

Collaboration

Learning

BUILDING S

Building S is based on the cultural activity of the Society sector, and the primary activities are oriented towards the arts and crafts; textile production, basketry, traditional cooking, Rwandan coffee and dairy production are social and communal interactions under the umbrella of 'Creativity'. 'Collaboration' is intended to happen in an outdoor space, through experimenting on coffee farming & growing a vegetable garden. In the same outdoor area, there will be an exhibition space to showcase the activities carried out with the other three sectors. 'Learning' activities can be conducted in the shared amphitheater with Building B and the workshop space on the second floor of the Building S.

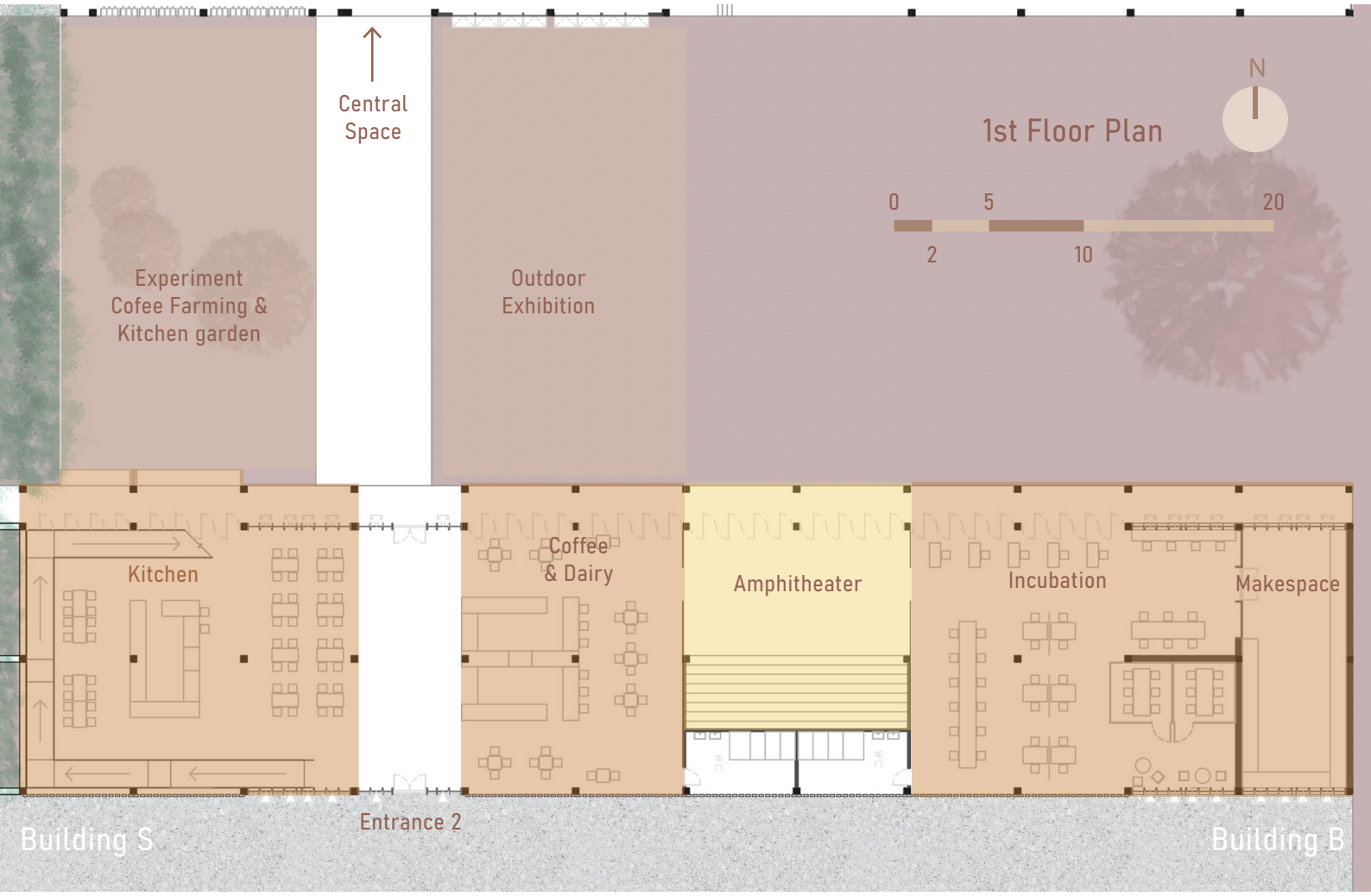
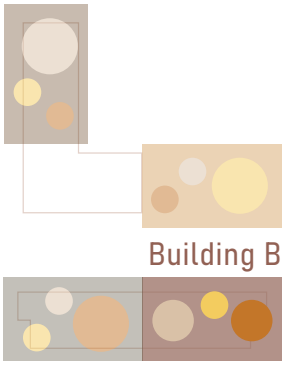


Figure 3.18. First floor plans of Building S and Building B



- Creativity
- Collaboration
- Learning

BUILDING B

The Business sector is represented by Building B, which is connected to Building S through the shared amphitheater, symbolizing the relation between business operations and society. The functions encourage interactions within the topics of 'Creativity' and 'Collaboration.' The functions on the first floor, Incubation and Makespace, are creative spaces that invite people outside of the university, students on the campus, and alumni to co-create new business ideas. The functions on the Second floor, Co-working and Startup, are flexible and leave room for collaborations, and along with the green and meeting space they provide a fertile environment for creative working to flourish. Although the interactions in the form of 'Learning' are a minority in this building, the aim is for the learning activity to happen spontaneously, through the collaborative working procedures. Events, seminars, public lectures, and exhibitions can happen at the shared amphitheater, at the central space, and at the available conference rooms at Building P.

Figure 3.19. Second floor plans of Building S and Building B

CIRCULATION

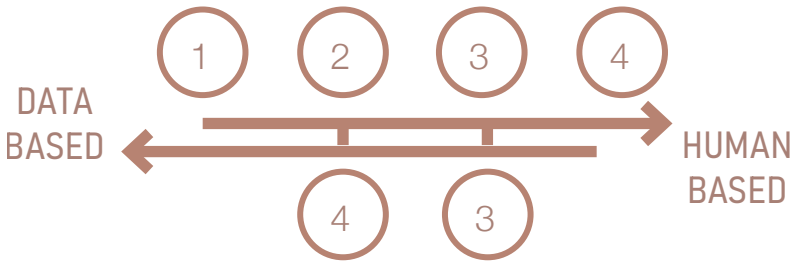


Figure 3.20.1. Circulation within the design proposal

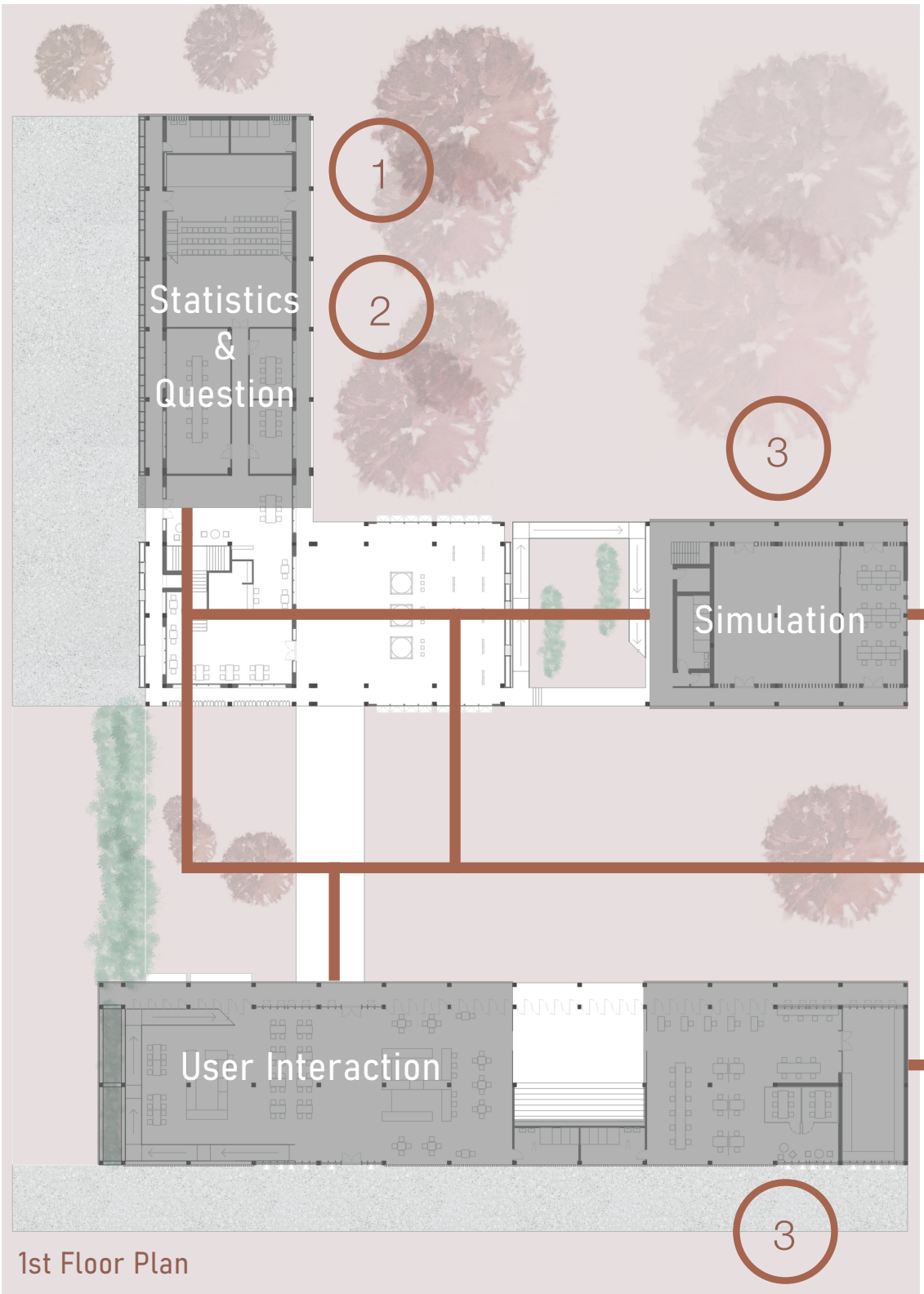


Figure 3.20.2. First floor Circulation

The circulation facilitates bidirectional learning by encouraging the flow of collaborative learning and working between the data-oriented learning processes and the human-based learning processes. In addition to that, the central space acts as an intermediary to push the innovations back and forth in the learning cycle.

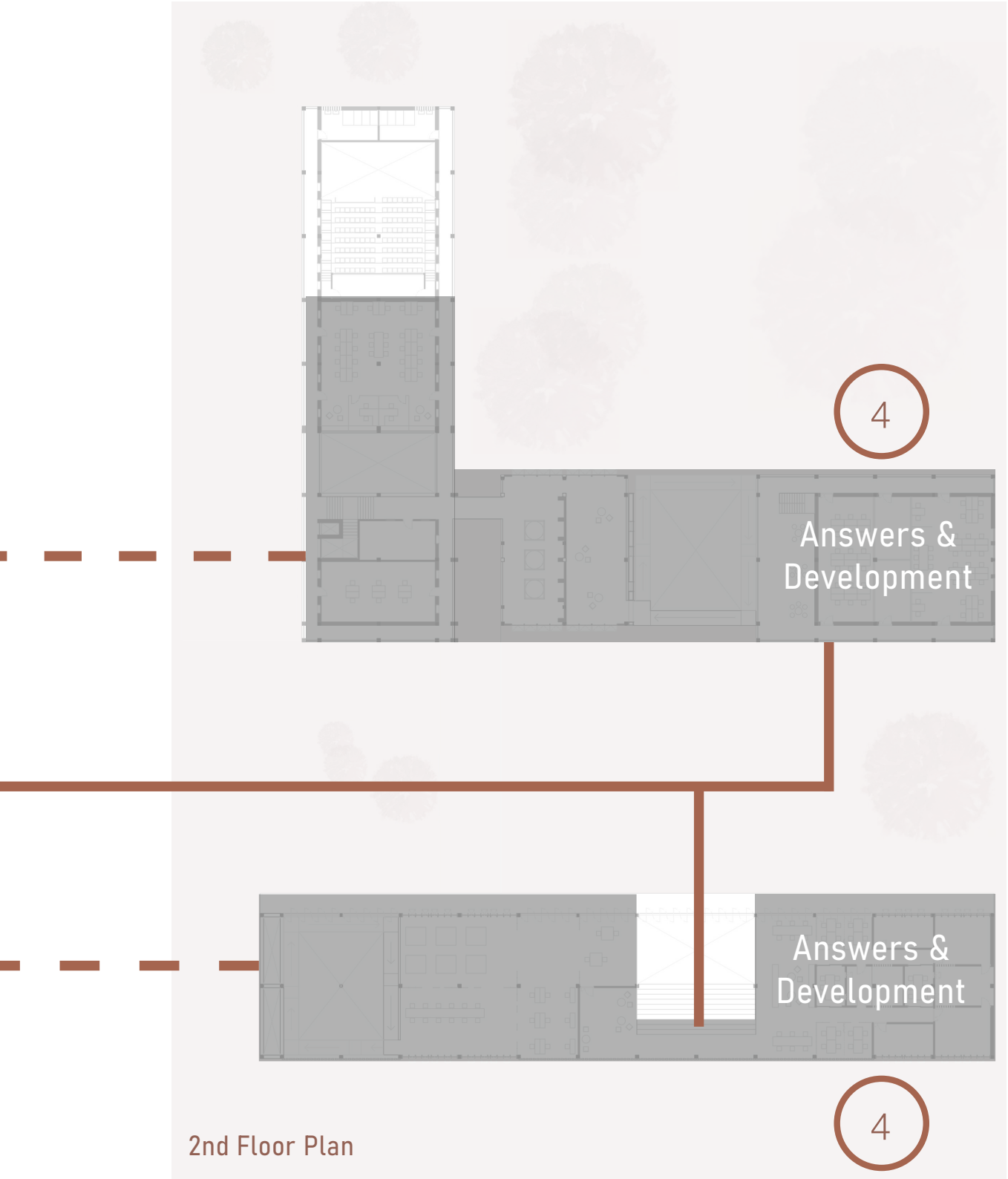
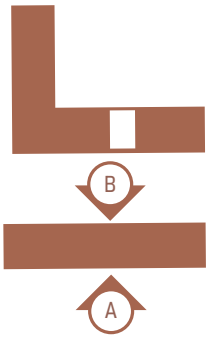


Figure 3.20.3. Second floor Circulation

ELEVATIONS



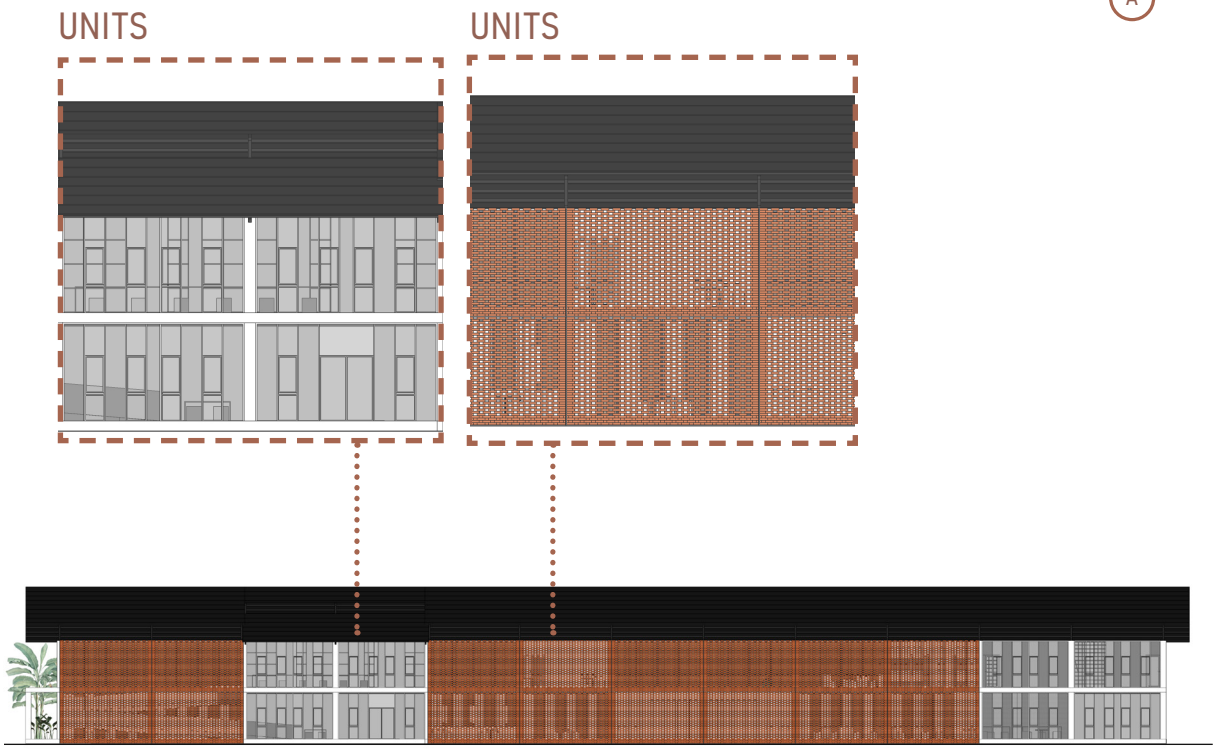


Figure 3.21. Elevation A

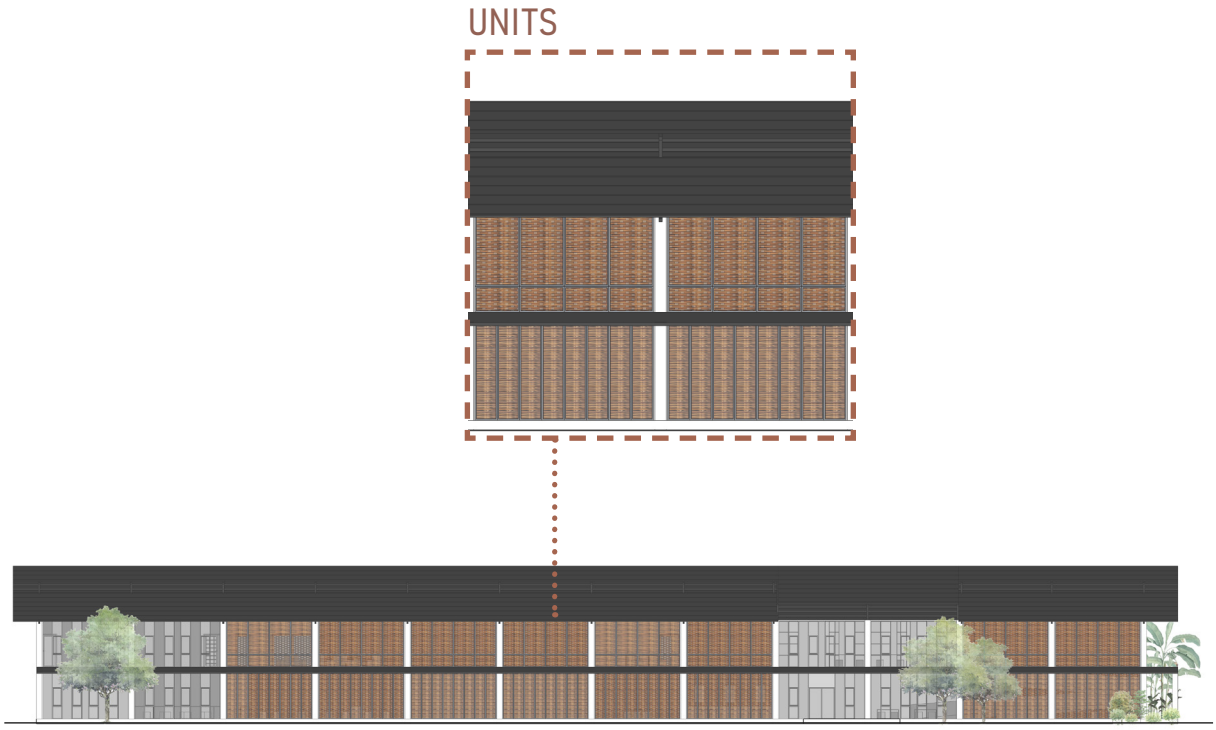
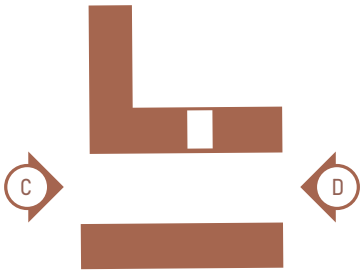


Figure 3.22. Elevation B



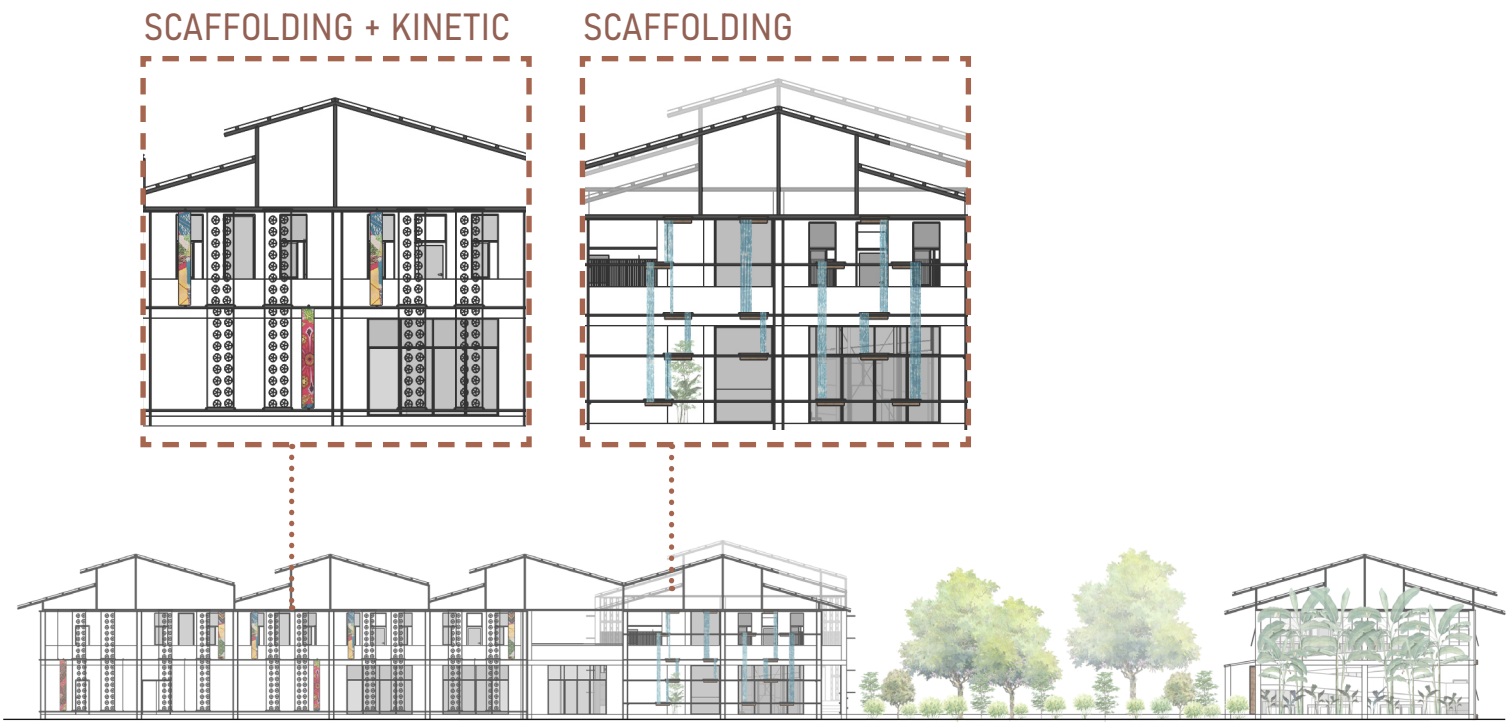


Figure 3.23. Elevation C

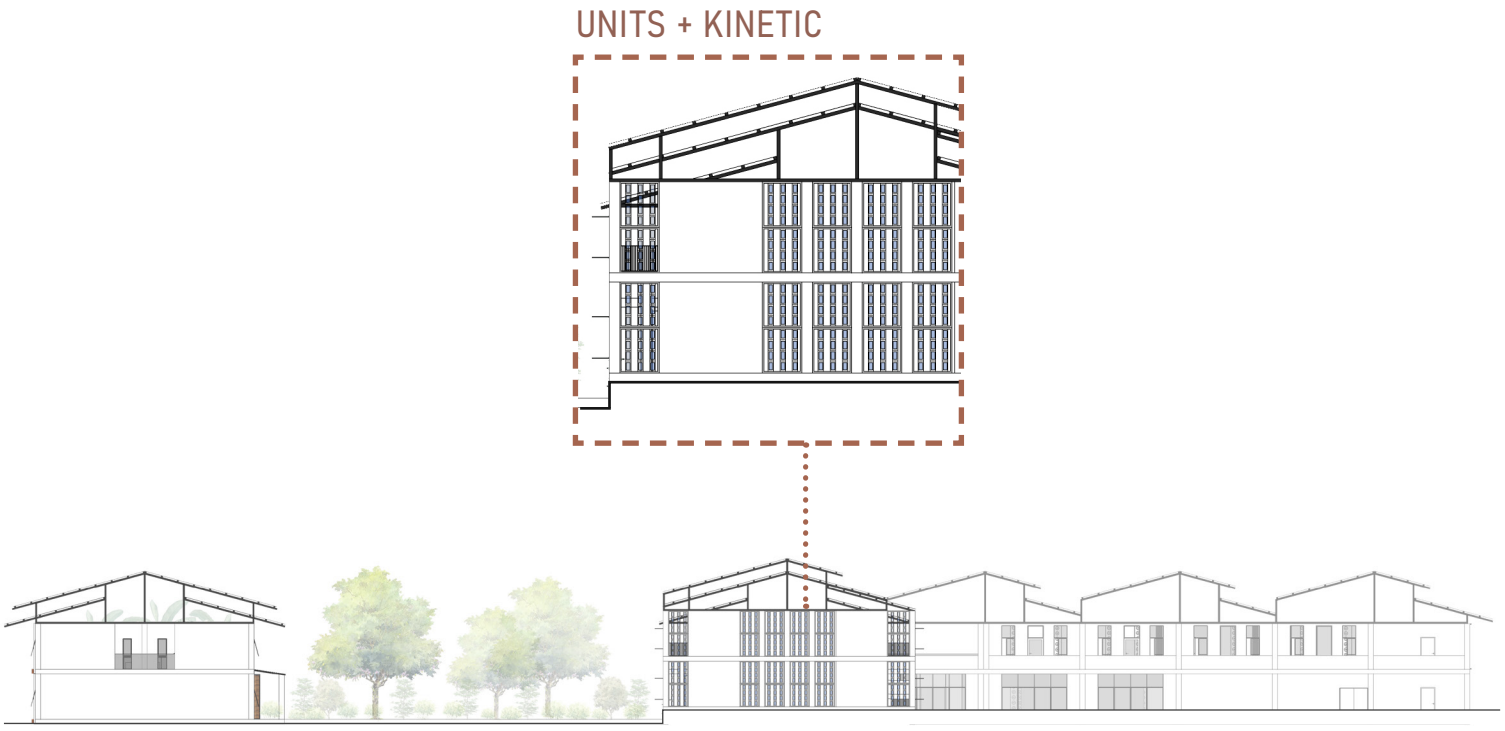


Figure 3.24. Elevation D

SECTIONS

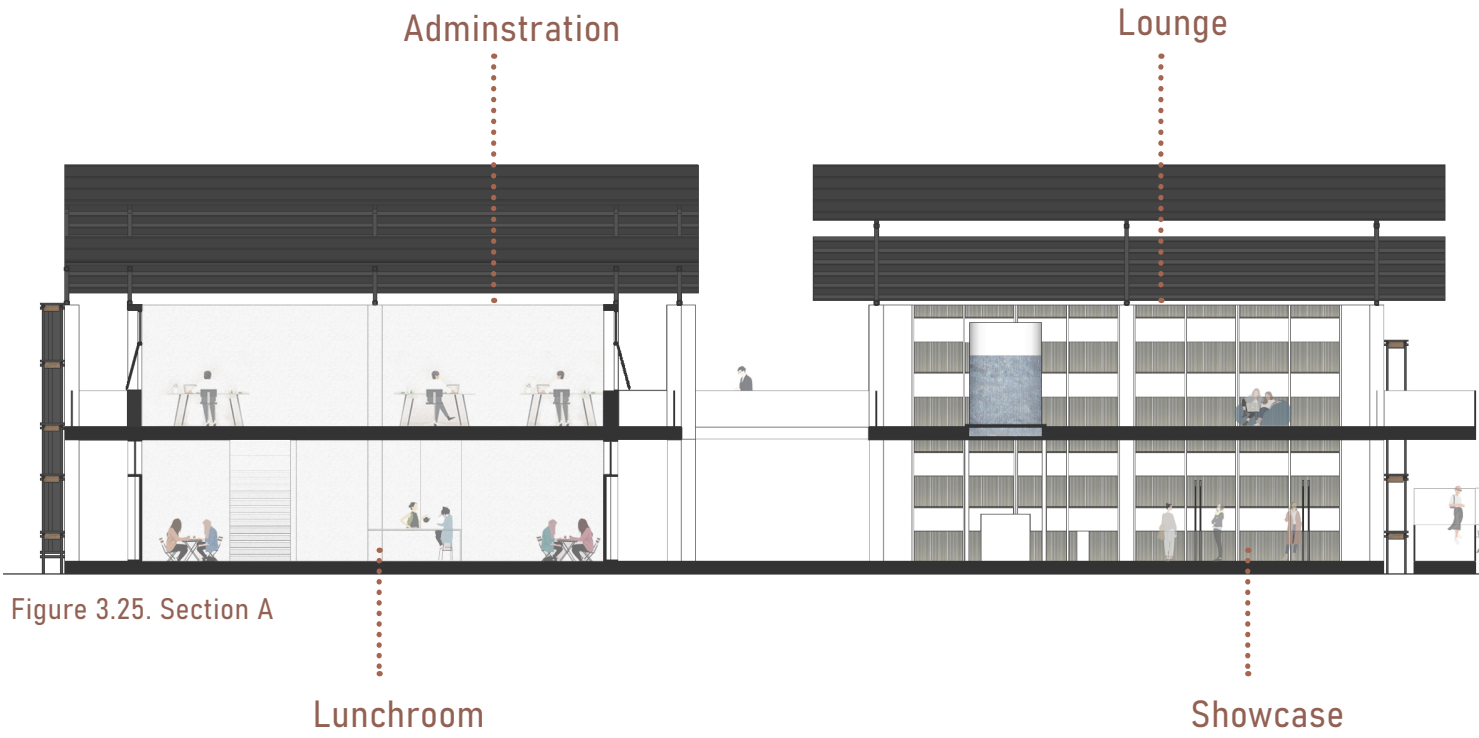
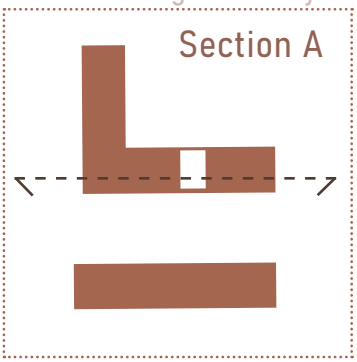


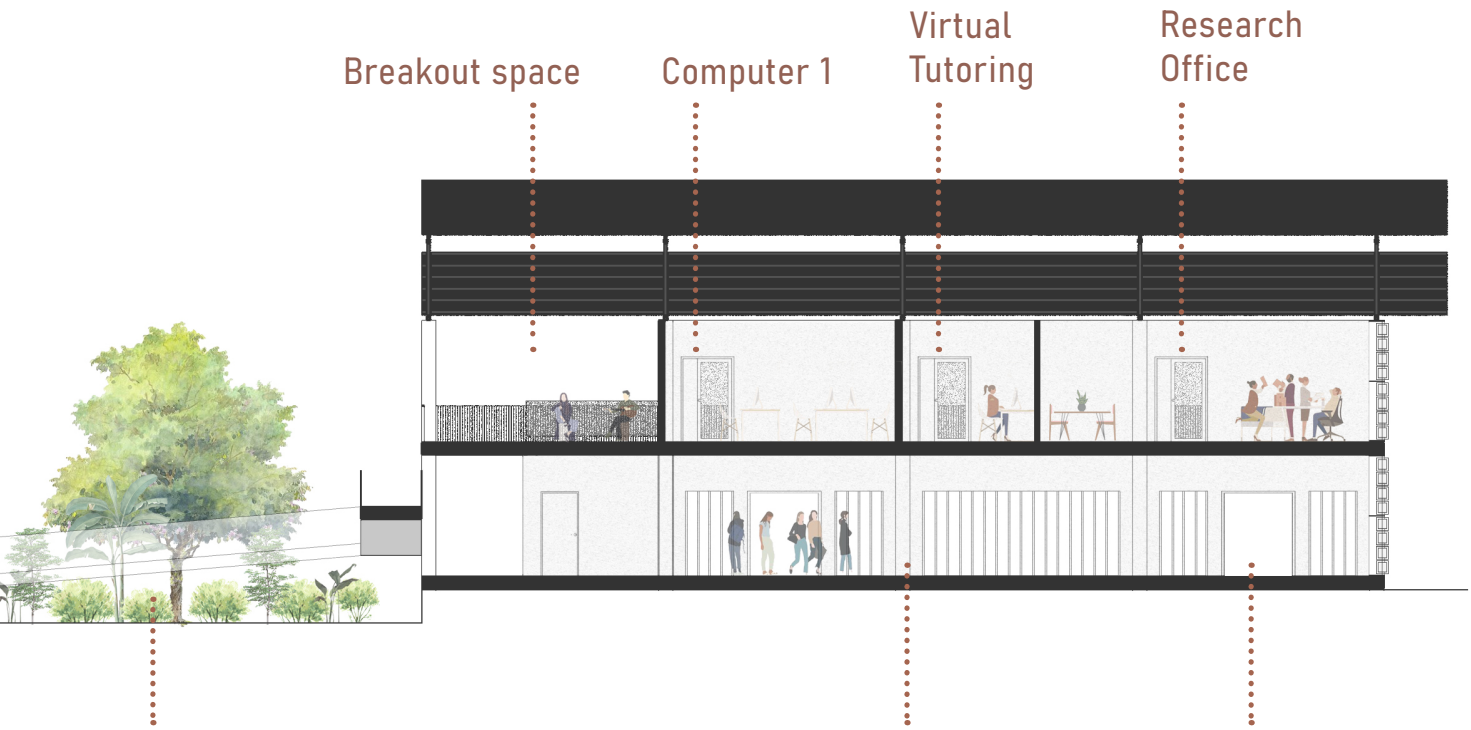
Figure 3.25. Section A

Central Space

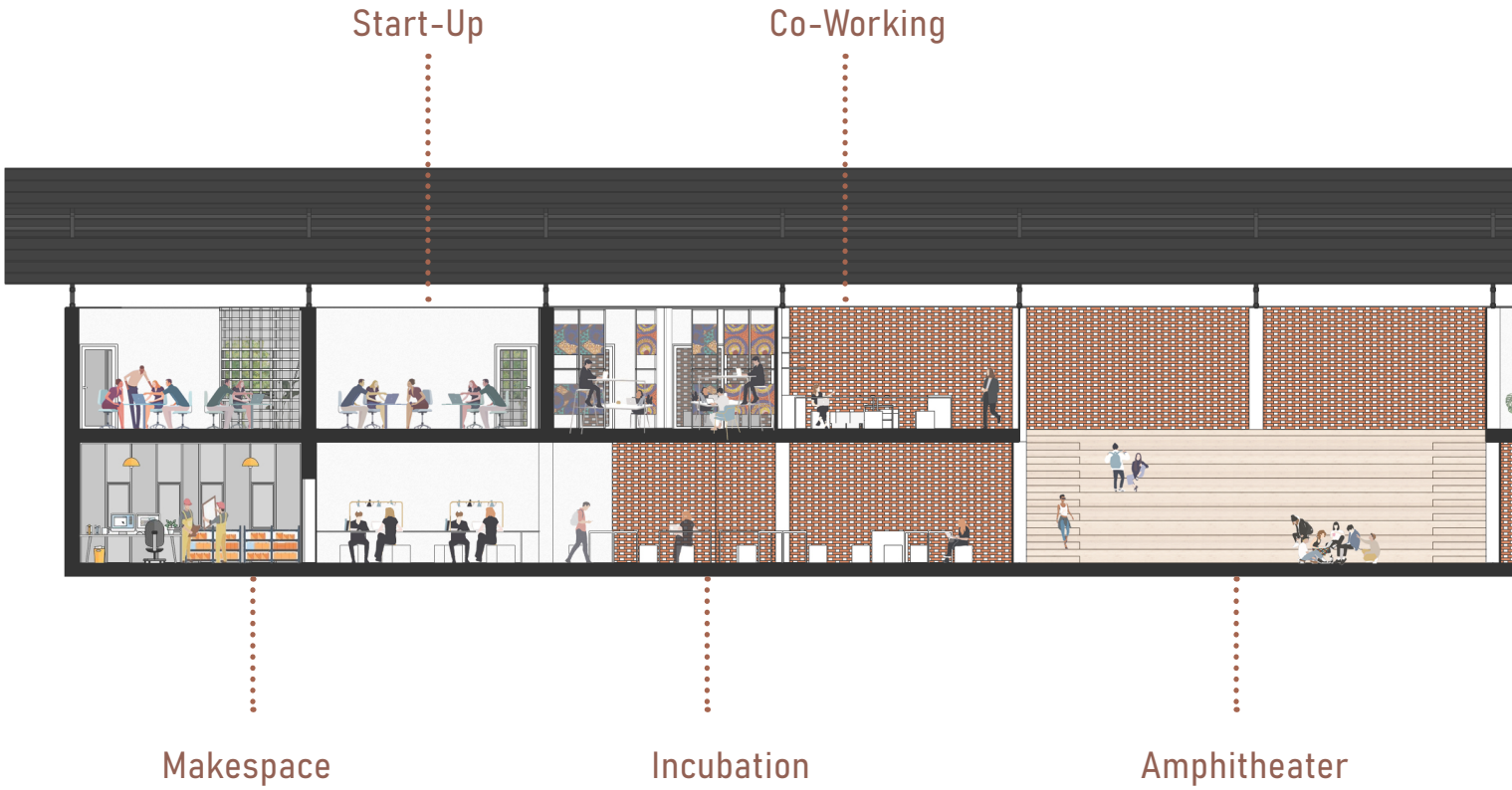
MEETING & BUFFER

The lunchroom, the garden, and the exhibition space are located in between the main buildings, near the central space in order to connect and facilitate people's movement, both main users and visitors in between the different parts of the complex. Each building needs a private space, so the space for occasional meetings and events is a good opportunity to be a meeting spot and a buffer zone.


Section A


Breakout space
Computer 1
Virtual Tutoring
Research Office
Garden
Laboratory
Computer 2

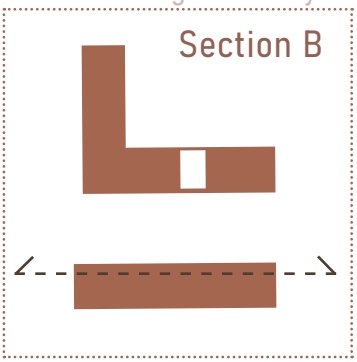
BUILDING P



Building B

SHARED & OWN

Between the different scales of organizations there are different levels of flexibility where working and learning can occur. The flexible partitions that can be applied on any shared space can create a room that fits any group of people. The partial boundary also creates a visual connection to others.



Textile & Basketry

Coffee & Milk

Kitchen

BUILDING S

FORMAL & INFORMAL :

The amphitheater can be used for formal public lectures in business and community events, but also for informal recreational events and art performances.

PERSPECTIVES

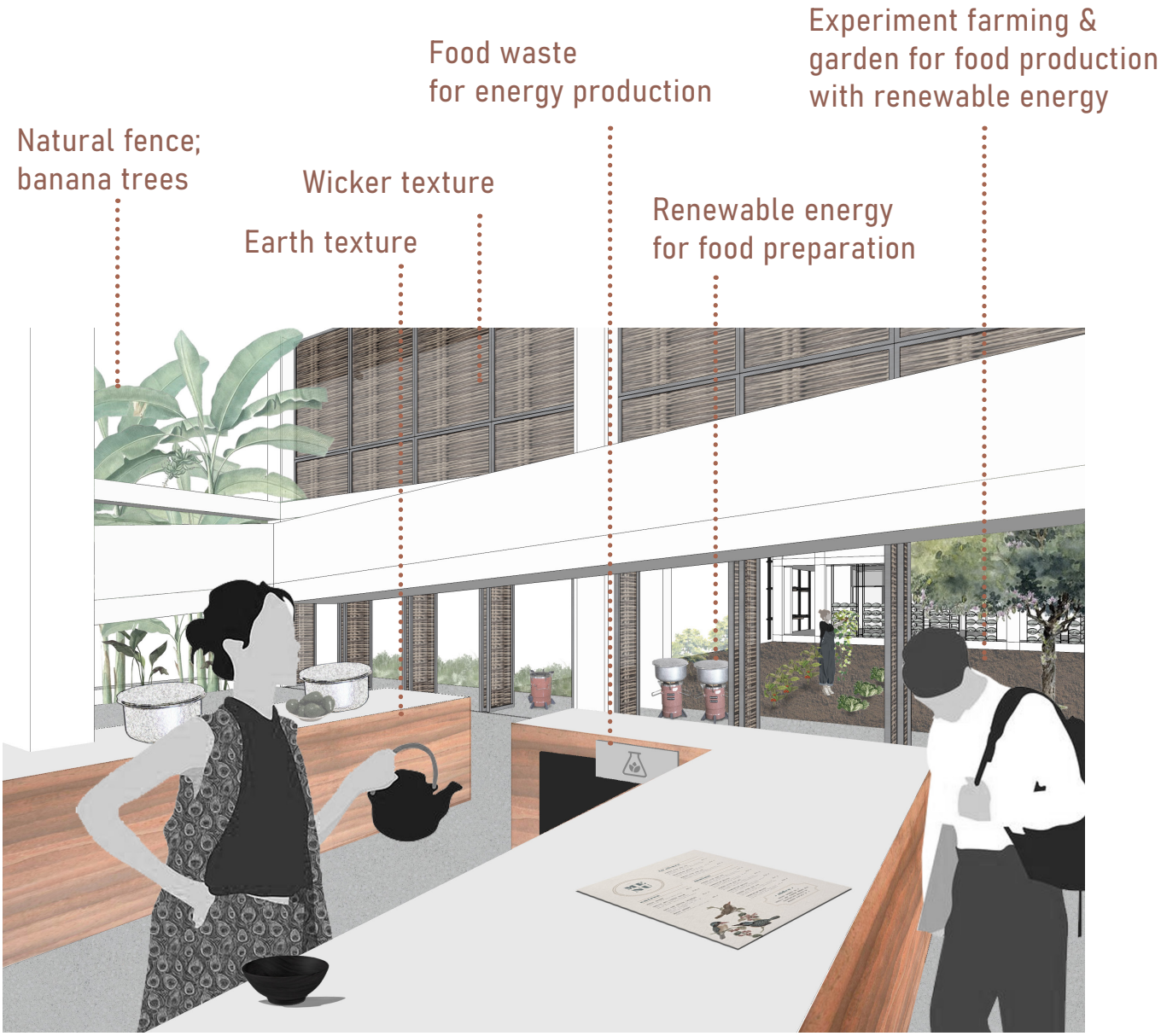


Figure 3.27. Perspective of the kitchen in the Building S

TECHNICAL & TRADITIONAL
USABLE & SENSIBLE

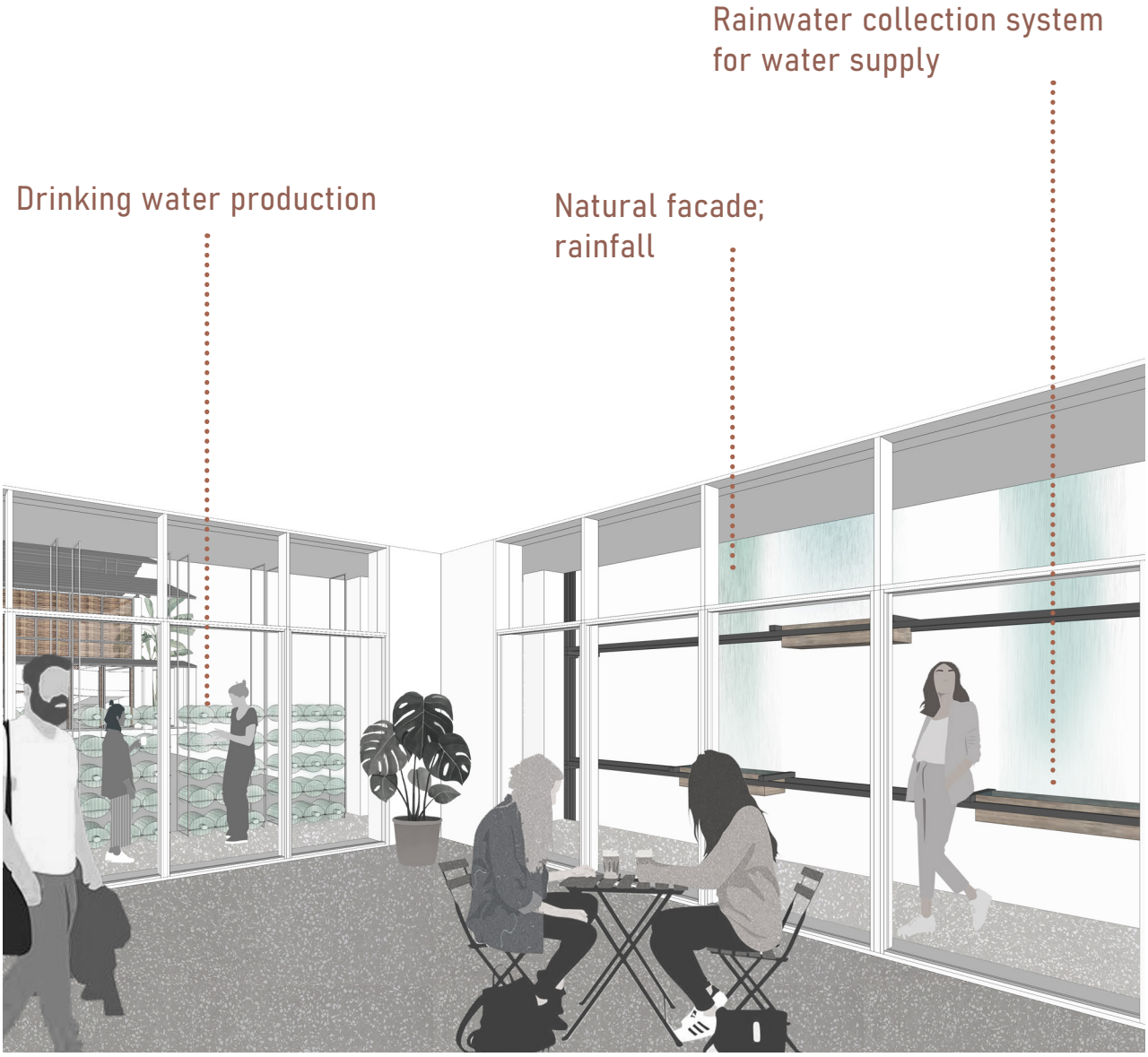


Figure 3.28. Perspective of the lunchroom in the Central Space

TECHNICAL & TRADITIONAL
USABLE & SENSIBLE

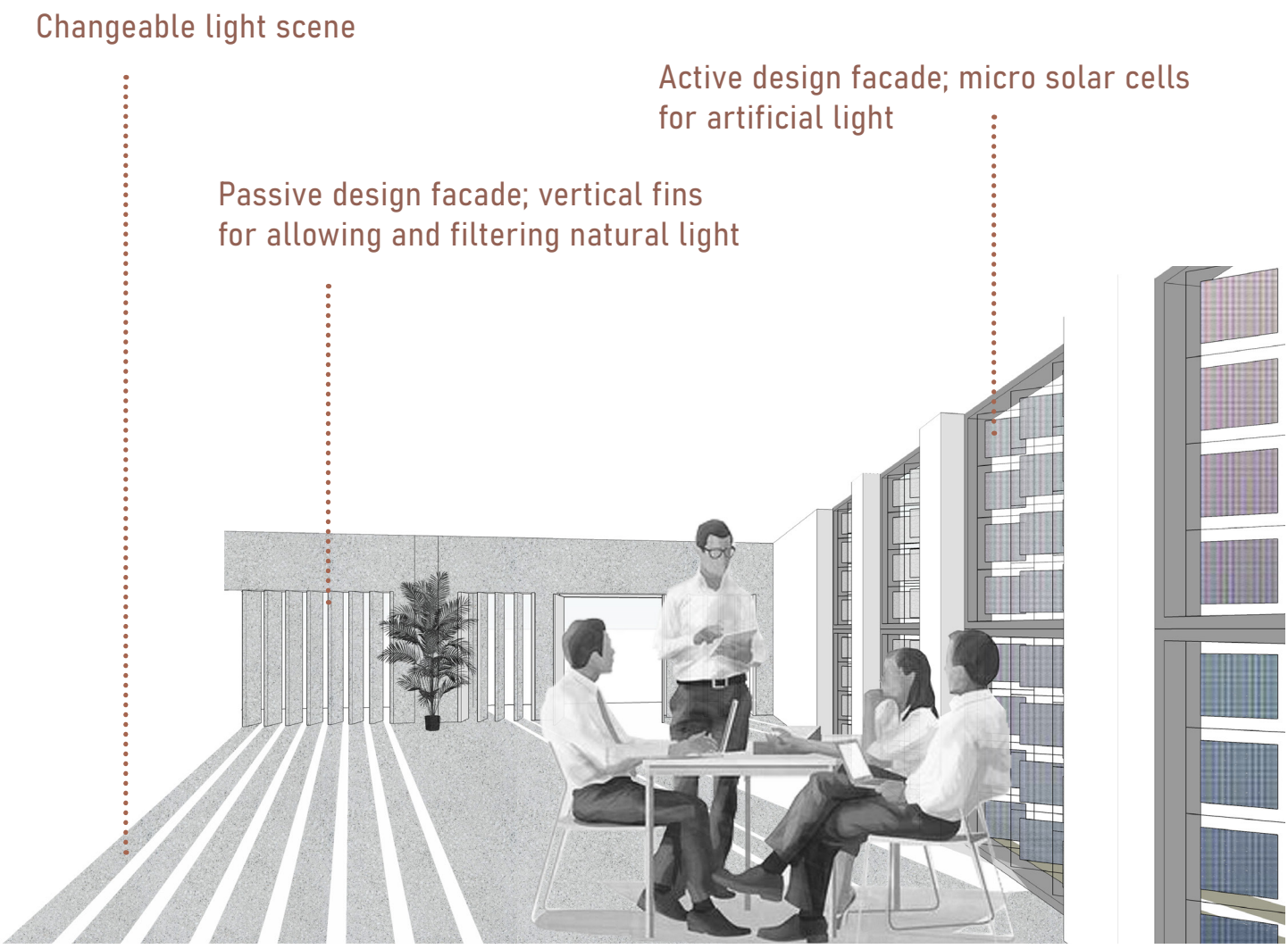


Figure 3.29. Perspective of the research office in the Building A

TECHNICAL & TRADITIONAL
USABLE & SENSIBLE

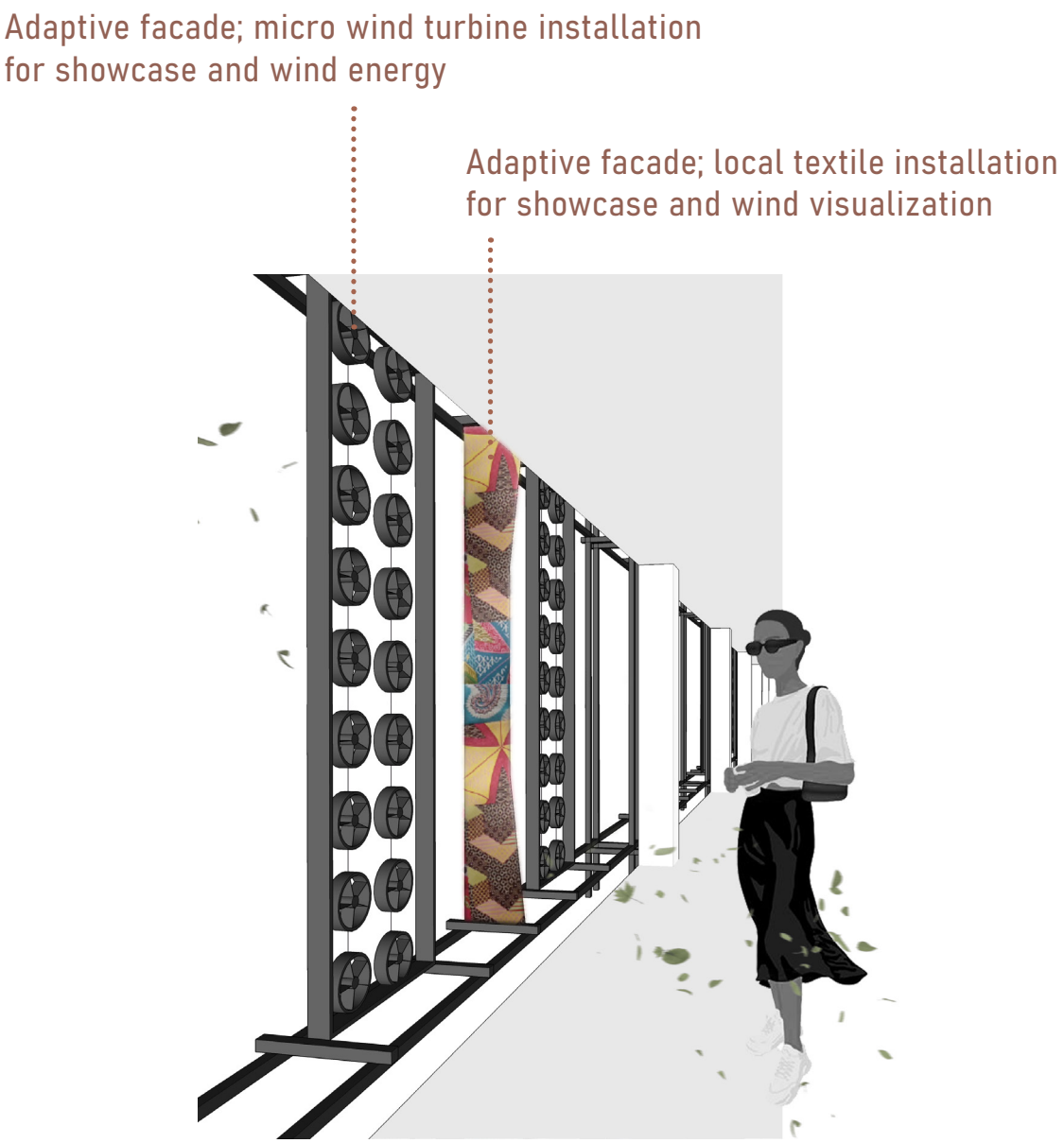


Figure 3.30. Perspective of the West side corridor in the Building P

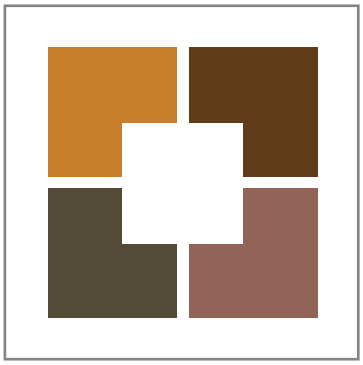
TECHNICAL & TRADITIONAL
USABLE & SENSIBLE

Data Collection 03

This phase is the result of the investigation through the implementation of the theoretical and the conceptual research. The outcome is a design strategy which utilizes certain architectural elements in order to foster a comprehensive innovation system. This is achieved through establishing and strengthening bidirectional and transdisciplinary exchanges while embracing the duality of contradictions.

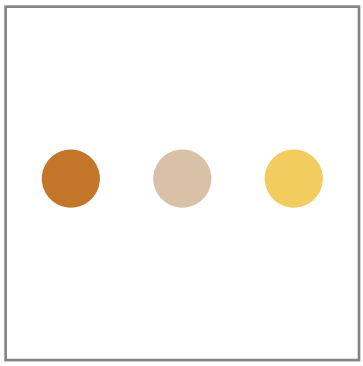
DESIGN STRATEGY

QUADRUPLE HELIX



The design elements defined through the theoretical studies can be fundamental in creating a comprehensive innovation system. The variations are depending on the cultures of the actors involved. The patterns of creativity, collaboration, and learning can be different from community to community. Also, the circular process of the system depends greatly on each institution's pedagogical approach and the organization's overall strategy.

INTERACTIONS



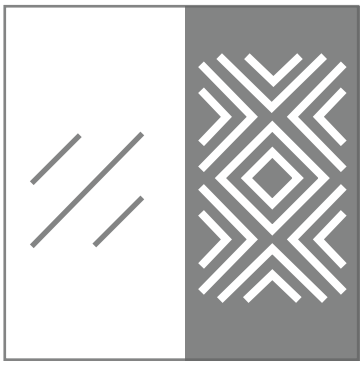
Through the concept of contradictions, the design elements are reinforcing the theoretical design elements and this can be highly contextual, depending on the site and location. However, the international & local communities along with the overarching value of natural resources pushed the architectural design to "cooperate" with the context. Industrial and vernacular materials create an environment that can attract multiple actors. The elements of Meeting & Buffer, Shared & Own, and Informal & Formal are necessary to foster creativity, collaboration, and learning. Also, technical & traditional tools and useable & sensible components provide great support to the data-oriented and human-based activities in the circular process.

CIRCULAR PROCESS

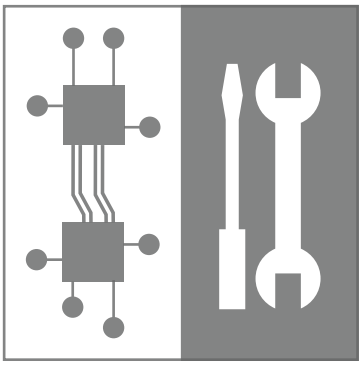
Figure 3.31. Illustration of the design strategy, based on the theoretical study

INTER-LOCAL

NATURAL RESOURSES



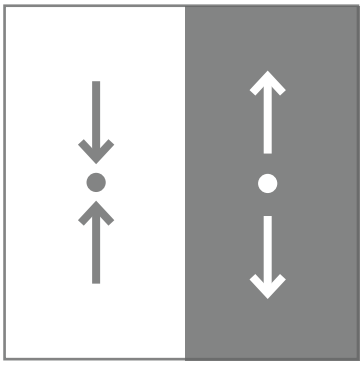
INDUSTRIAL & VERNACULAR



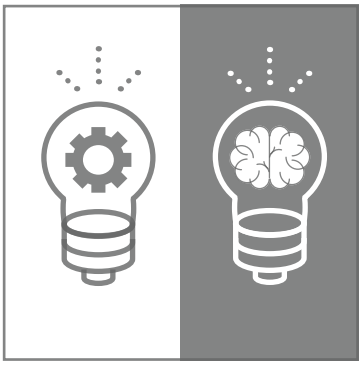
TECNICAL&TRADITIONAL

MATERIALITY

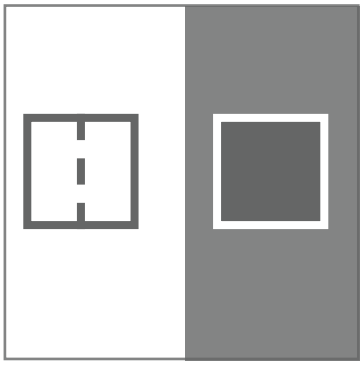
IMMATERIALITY



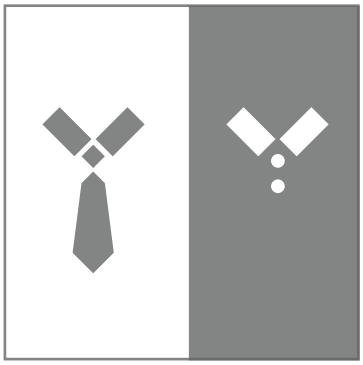
MEETING & BUFFER



USABLE & SENSIBLE



SHARED & OWN



FORMAL & INFORMAL

Figure 3.32. Illustration of the design strategy, based on the concept of contradictions

It all began with a curiosity in transdisciplinarity, the collaborative actors, the interactive forms, and the circular process that was introduced through the theoretical research. The combined theories formed the notion of a 'Comprehensive innovation system' within the transdisciplinary approach. When the study of the context started, a design approach with the concept of the contradictions was created. The contradictions led to the notion of 'Duality' and 'Duality' led to the material and immaterial dichotomy as observed in the architectural space and the design elements.

Regarding the architecture of this proposal, theoretical and contextual research were translated into a design proposal with the properties of Duality. This proposal aims to promote the coexistence of different cultural values with seemingly contrasting characteristics. The question of artificiality and humanity was addressed regarding the co-learning environment, and in response to the international and local communities' learning and working patterns, employing both technological instruments and human perception and abilities. (Figure3.32.) This, in order to promote bidirectional Learning and relations within the educational space. Both professionals within academia and science and people outside the research community can be participants and advance the comprehensive innovation system.

On the other hand, this research was carried out in a context (referring to the broader Rwandan context) with very specific characteristics such as insufficient economy, unequal society, and a centralized government. It requires active participants with relevant skills and knowledge, as well as an empathetic approach. This study still needs more disciplines involved and more actors from the different sectors in the research procedure. The design approach with the contradictions can be further adjusted and improved by involving other disciplines and actors. Also, the design strategy of the case study - the ACE-ESD Co-innovation Hub, was investigated in terms of architectural analysis and proposal development within a limited amount of time. In further development of this case study, or when applying this strategy to other case studies, there are more challenges, but those challenges can provide points of departure for other design approaches.

Reflections

REFLECTION ON THE MASTER THESIS PROCESS

Due to the case study being a pilot project, the initial stakeholders are mono-disciplinary. This affected study phase 1, and the possibility to identify actual actors from the four different sectors on-site was limited. The different national regulations made the data collection difficult. Additionally, the different timeframes, working between disciplines, and multicultural groups took time to manage along with having to adjust the research methodology. It was a challenge to push the ideas forward to design (phase 3). When collecting data in unfamiliar and complicated contexts, culturally biased perception can be a tricky issue through outsider or insider perspectives. The study process needs discussion and careful analysis. The research would be more qualitative if there was a possibility to work together with sociologists, political scientists, or economists in order to avoid misinterpretation.

REFLECTION ON CO-DESIGN

Starting the collaborative design in the early stage of formulating a project can have disadvantages when taking into account the unclear positioning of the team and the blurry responsibilities. The team members and stakeholders have individual interests and expectations which were not identified clearly in the beginning. The initial process is confusing, and formulating a clear, shared vision takes time. Different expectations created through the visual material used during the process also had to be managed. Frequent communication is key in this process and all information must be properly shared.

The varying time frames as well as the different working cultures resulted in people having different priorities. Also, the low position of the author (i.e. a student), the foreign status, and the lack of compensation for participating made people lose interest in doing so. This affects the ability to stick to a preconceived schedule. It takes time to understand the hierarchical structure, to rearrange the working strategies such as creating official letters, and to partake in communications with people holding high positions.

AUTHOR'S REFLECTION

I was born and raised in Thailand, a developing country in the so-called "third world", just like Rwanda. Creative and interactive cultures are thriving in Thailand, but they have not yet fallen into place. This is happening due to the enormous gap between social classes and educational levels which halts any attempt towards a holistic approach and collaboration between the public, private and academic sectors and the poor communities who are the majority of the Thai population. We have been facing the same challenges in balancing the powers and reaching equity. In this age of information, people with great power and influence who possess higher technical, digital, and financial tools are perceived as leaders. People with less or no power have been following the leaders; they are gradually losing their identity, self-esteem, and traditions. Studying design for sustainable development in a developed country in the "first world", and conducting this research in East Africa, helped me to learn a lot and enabled me to see things from different perspectives. My conclusion is that everyone has both advantages and disadvantages, something to learn and something to offer and this is the reason why I am eager to co-learn through cultural differences. Social design is my main focus. People reflect (on) the society, set up the norms, and drive the intellectual movements. In global complex problems, a collective and cooperative method for in-depth solutions is a tool that we should be trying to encourage. I question how transdisciplinarity applies in different contexts. And this master thesis was an opportunity to investigate the transdisciplinary approach in a developing country context through architectural design.

As mentioned before, transdisciplinarity involves working with many different cultures, and it's highly dependent on the culture of the context and the actors. It requires high motivation and an open mind to start the process, especially in a hierarchical, capitalist, and western-influenced society. Therefore, other aspects of values have to be seen and heard in the community and nation. The multicultural perspective and involvement are still needed to reflect what we have, what we miss, and what we need to develop in order to achieve an efficient system; in addition, willingness and transparency are essential elements in this process.

In the architectural world, globalization is unavoidable. We work across the world, and we have to deal with multicultural project sites, teams, and prospective users. We have to face the complexity of architecture in terms of functions, constructions, business models, and technologies in different contexts. Countless innovations come to life across the globe, but a lot of cultural innovations remain hidden. We cannot be knowledgeable into all regional issues. As an architect, I hope that I can be a facilitator to raise awareness on different important values through my architectural practice and approach. Architecture is not just for the architectural outcome itself, as a physical creation, but also the design process, the careful thinking, the learning, and the sharing of knowledge through different angles and perspectives. This study is one approach to illustrate the values of difference and diversity; the knowledge inside or outside of academia, in both global and regional scales, which could be supportive of each other. Even though differences sometimes create boundaries, they can also create a path to mutual exchange and push for change and advancement.

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LIST OF FIGURES

APPENDIX A

INTERVIEW QUESTIONS

A – Process for co-innovating sustainable energy or general work:

1. What is your work about? How is it related to Sustainable energy/ innovations?
2. When you start a new project, do you run through these process below? And How?
    - Theory and Laws / understanding
    - Prediction/shared vision
    - Implementation/ learning by doing
    - Data Collection/ Behaviors and Observation
    - Inter- and Trans-disciplinary in the Organization
3. How much of your work needs interaction with other people or other organizations?
4. Have you worked with interdisciplinary approach (in projects or teams involving with different disciplines) before? If yes, with which other disciplines?
    a. What are the challenges? And how do you make the work successful?
    b. In terms of society, what is the difference and similarity between your organization and theirs?
5. Have you worked with trans-disciplinary approach (in projects or teams involving with lay-person or community) before? If yes, with which other disciplines?
    a. What is the challenges? And how do you make the work successful?
    b. In terms of society, what is the difference and similarity between your organization and theirs?

B - Interaction with Creativity, Collaboration and Learning in the Organization:

6. Could you tell me about your (organization) routine activities?
7. How do you achieve creativity in your organization?
8. How do you collaborate in your organization?
9. Do you have any learning activities in your organization and how?

C – Relationship with the region:

10. How do you (or your organization) be influenced by Kigali/Rwanda ociety?
11. How do you (or your organization) influence to Kigali/Rwanda society?

INTERVIEWEE

Due to local rules and legislations, the author is not at liberty to reveal the full transcripts of the interviews. However, interviewee identities can be disclosed and the notes from the interviews can be included. The following text is the detailed description of the three official interviews and the additional informal interview that took place in the form of a casual conversation.

Interviewee #1

She is a Ph.D. researcher in the Renewable Energy programme at the ACE-ESD center. She is from Nigeria and this is her third year of the Ph.D. programme (2020). She regularly conducts her study at the campus in the researcher offices. She is contact with a lot of colleagues, she is engaged in different kinds of research in the other two programmes, and she is actively working to improve the academic approach of the ACE-ESD.

Interviewee #2

He is the Deputy Director of and a professor in the department of Electrical Engineering in the ACE-ESD Center. He was also involved in the SIDA-funded partnership for creating the ACE-ESD Co-Innovation hub as one of the team leaders. He was able to provide information on the functions of the ACE-ESD as an academic institution in Rwanda and on the teaching and learning behaviors of engineering students, instructors and administrators at the University of Rwanda.

Interviewee #3

He is a Professor at the College of Business and Economics, University of Rwanda. The college is located on another area that is close to the Nyarugenge campus. He was invited to be Head of the Incubation Center at the ACE-ESD Co-Innovation hub. He was able to provide different perspectives on learning through his affiliation with the College of Business and Entrepreneurship, and on the relationship between colleges and communities.

Interviewee #4

This person is part of a business/organisation working with social issues that receives funding from foreign organizations. This organization has experiences of working across cultures and disciplines since they have been working on many projects with local and international communities. The conversation with the manager revealed a way of active and collaborative working, under the vision of an international organization in the Rwandan context.

Interviewee #1

A: Process for co-innovating
On the PhD level, there are three programs that work collaboratively within the organization. They are multi-disciplinary and revolve around renewable energy systems. The renewable energy field within ACE-ESD is quite mixed in terms of disciplines; Mechanical and Electrical Engineering, Science, Physics and Agricultural engineering. The power system is quite technical; it includes Mechanical and Electrical Engineering. Energy economics is the technical discipline that pursues changes in terms of policies, regulations and economics within energy related topics.
In general, the way the researchers of ACE-ESD operate is to first contact public organizations or companies to get the necessary data and statistics. Then they develop research questions. After that, they find the labs in which they can conduct experiments and simulations with the aid of computer programs and software, depending on their project method. Approaching public and private organizations, with the aim to get contacts and access to their networks that will ultimately lead to accessing the necessary data, can be a challenge. Normally, they are supportive of students but they expect to see an official request in the form of the letter from the University before sharing any information.
She does not work with the community during the research process. In her opinion, people have no idea about renewable or sustainable energy. In addition, there is the language barrier that makes communication harder. Another thing is when the researcher has come up with a solution, but the African/Rwandan context cannot support it, as it is rarely the most affordable option for people. Since the end users are the people, the whole process is highly dependent on being accepted by the general public.

B - Interaction with Creativity, Collaboration and Learning activities
Normally, researchers come to the office round 8-10 am. , they work on their individual research projects, and leave the around 9-10 pm. Some people start leaving around 4 pm. They have meetings once a week with their supervisors -2 to 3 supervisors for each researcher. Some professors are not in Rwanda, so virtual meetings are not an unusual feature. Additionally, they have to attend public lectures or international conferences, where they present their papers. In general, they participate in academic events to get more feedback and input for their research.
According to the interviewee, the research process consists mainly of working on data and statistics, and it is lacking excitement and creativity. So, she goes to do other, more creative activities instead, for example training in the gym, playing tennis, visiting the nature outside Kigali, cinema, and sometimes shopping. She also enjoys going to the church to sing and practice the piano. The ACE-ESD collaborates with the partners of the University of Rwanda and most people are welcoming when somebody needs to talk. One can go directly and ask people for help or whatever may be needed, but people can be quite reserved, compared to her country of origin (Nigeria). The learning activities take the form of events or energy expositions, which provide opportunities to create and expand one's network, partnerships, inspiration, which will help in coming up with solutions that can have some real impact on society.

C – Relationship with the region:
Regarding her background, her home town in Nigeria is quite noisy and ever-moving which is in contrast to the much calmer Rwandan lifestyle. This helped her become calmer and more patient as a person. Rwandan food has no variety of choice, according to her. On the other hand, the city is always clean, something which is lacking from her hometown in Nigeria. This says a lot about the Rwandan Culture; people behave responsibly and keep their surroundings clean.
Regarding the academic experience at the ACE-ESD, the University has training sessions for East and South African scientists about energy and public lectures. They are online events and open for everyone that might be interested. But the university focuses on and needs people who have relevant skills and knowledge to the themes tackled by the different programs.

Interviewee #2

A: Process for co-innovating

He is a lecturer at the University of Rwanda and holds the position of deputy director of the ACE-ESD. He is also one of the collaborators within the SIDA-funded partnership. Normally, he starts working on a project by establishing a shared vision among the different partners involved and then taking action. Theoretical processes are not really included in his scope of work, but he does employ them when teaching. His job dictates that he needs to be in contact with public offices, energy organizations, and private companies. This is the first project that he is working on that employs an interdisciplinary approach. He perceives it as a good opportunity, but also a challenge to focus on the task and deal with the different fields and many organizations involved. The amount of input and the potential directions that can be taken, can be overwhelming and this is why he is striving for the best way of combining and communicating ideas. Negotiation is a necessary element in order to not lose sight of the initial goals, including the responsibility of an academic institute to produce and publish knowledge and technology. Even though this is his first project with an interdisciplinary approach, he is eager to work in a transdisciplinary way in the future.

B - Interaction with Creativity, Collaboration and Learning activities

The routine of the university staff dictates that all employees have to punch in and start working. Breaks can be taken whenever, according to each individual employee's needs. The most common time though is lunchtime. There is usually a lot of work, so he goes home with extra tasks to finish. Vacations take place during Christmas and the big study break is between July and August. The latter is usually not a busy period, so this is when preparations for teaching and the setting up of new projects occur.

He mentioned that through meetings with people from other colleges, as well as by working collaboratively with people holding different ranks in terms of hierarchy within the university, can spark creativity. The ACE-ESD has no full time staff, so people will have to be recruited from other colleges of the University of Rwanda. The university encourages the teachers and staff to learn, so workshops, seminars, and pedagogical courses are available all year round.

C – Relationship with the region:

For the students and staff it's easy to find new input and IT tools in Kigali. There are large businesses, big companies and public institutions close to the campus, which is something that fosters the connection to important resources and organizations. The different demands, the busy lifestyles and the workload are answered with the establishing of new evening programs to support the people who are not fully available or work fulltime during the day.

The staff of the University of Rwanda is frequently invited to the board meetings as a technical committee to provide technical consideration and academic input for public sectors and organizations.

Interviewee #3

A: Process for co-innovating

He is a lecturer in the school of Business at the University of Rwanda. He is in a specialist in entrepreneurship and innovation and he is invited to support ACE-ESD in business and entrepreneurship related matters. The research in business school is learning by doing through five steps.

1. Focusing on people and understanding their problems and particular issues in order to provide solutions
2. Conducting research on potential problems and proposing optimal solutions by narrowing down to the most probable issues that may be encountered
3. Testing prototypes with a group of users, in order to gain insight on user experience, and adapting the previous solutions
4. Creating optimal prototypes of products or services based on the above steps
5. Setting an evaluation period

Business is related to social sciences. No solution can be successful without understanding the behavioral patterns of end users. In his experience with interdisciplinary and transdisciplinary approaches, people understand what he is doing. But one must keep in mind that we have different (professional) languages and approaches, and we have to read between the lines. The processes of business keep changing, we need discussions that include different aspects to find the solution that works best.

B - Interaction with Creativity, Collaboration and Learning activities

His primary work is education; teaching at the school of business, conducting research and produce publications. Additional work is striving for community outreach in rural areas in order to support the community and improve people's lives through business-building, for example the business in the refugee camp.

Creativity is kick-started by hands-on activities outside the classroom. Collaboration also happens outside the lecture room, by reaching out and asking people questions. The business learning is connected to public and private organizations that are interested in academic investment, so the students learn through the labs and working closely with companies outside academia.

C – Relationship with the region:

He thinks that the existing situation in the Rwandan business sector is challenging when it comes to creating innovations. Moreover, working with companies means that their needs have to be taken into consideration. He is working as a private consultant, to distribute knowledge in different businesses.

Interviewee #4

A: Process for co-innovating

Their work depends on the topic and theme at hand, there is no specific field of operations. The topics are picked up from the partners, and the organization is tasked with finding people within its ranks that are going to work with each topic. They work mainly with design and their starting point is placing people in the center of their process. Their goal during the process is to find the stakeholders and network who can be involved with that topic. After that they set out to collect data either by visiting the site and talking to people, specifically the future users, and then repeat the process to further develop the projects.

B - Interaction with Creativity, Collaboration and Learning activities

They are based at the Hub, and their staff work on the third floor, in the co-working space. Their work is carried out mostly on computers, especially when preparing an exhibition or event at the hub. On the fourth floor there are multiuse spaces for both staff and visitors; there is a café and pub and spaces for exhibitions and various academic events in evening. These events can have between 30 and 100 participants, depending on scale and topic.

They interact with stakeholders and their network weekly through the hub's events. They work with an interdisciplinary approach, which is rather effortless for them since they have an established network and are quite approachable due to their good reputation as a young entrepreneurial organization. They also have experience with transdisciplinary approach, and it has worked quite well for them so far. They study people, communities and future end users of particular projects, focusing on their background and on their future plans in order to make sure that they have a right scope and right questions.

They have some challenging projects, such as the project in the refugee camp, where the difference in mindsets and cultural backgrounds were making the process of finding common ground a bit more difficult. The team was trying to understand all the different parameters before deciding how to proceed.

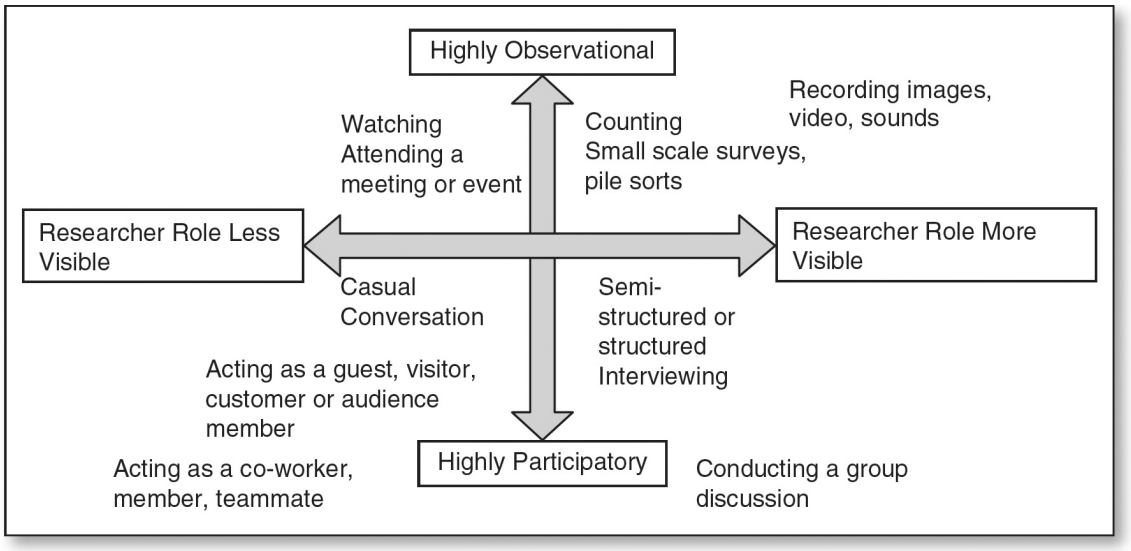
There are 2 layers of collaboration that take place in the organization. The first one is the collaboration with the network, which can greatly support in securing the process by providing quality input and active participants. The second is the collaboration with end users and visitors during events and activities. Their variety of topics depends highly on what the community deems interesting and important to tackle. This is how they get feedback and build the network.

C – Relationship with the region

The city of Kigali is quite developed, and there is visible influence of foreign cultures. But in general, people are quite laid back.

OBSERVATION & PARTICIPANT OBSERVATION

PARTICIPANT OBSERVATION CONTINUUMS



The participant observation continuums from the book Collecting Qualitative Data: A Field Manual for Applied Research, by Guest, G., Namey, E. E., and Mitchell M. L., (2013). Chapter 3 Participant observation.

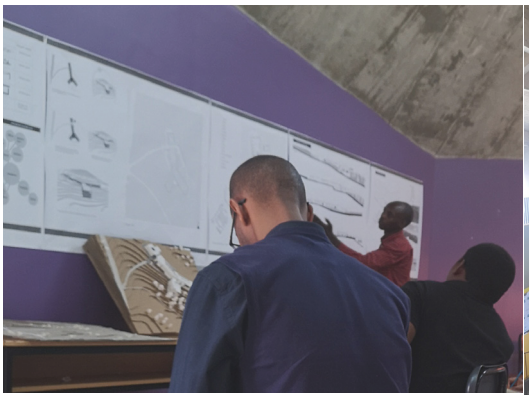
Academia
- Attending a presentation of Bachelor thesis students
- Visiting studios, classrooms, a laboratory and instructor offices
- Working in a staff office and a researcher office of ACE-ESD center, a student's studio in architecture school and the Library of the University of Rwanda on the Nyarugeny campus

Society
- Living in Nyamirambo Areas, six and a half weeks.
- Attending basketry workshop with Nyarugenge women's center
- A customer of the local grocery, markets, milk bar, medicines, phone and internet service
- Visiting a youth center and local artists' galleries.

Business
- A customer and attending coffee workshop with Question coffee, a social enterprise
- Visiting start-up, co-working, incubator business
- Visiting an architectural design company

Public Sector
- Contacting National Council of Science and Technology for research permit application
- A month member of Public library of Kigali city

Architectural Master Thesis student presentation ,the University of Rwanda, (2020, February 26)




School of Architecture and Built Environment, the University of Rwanda.

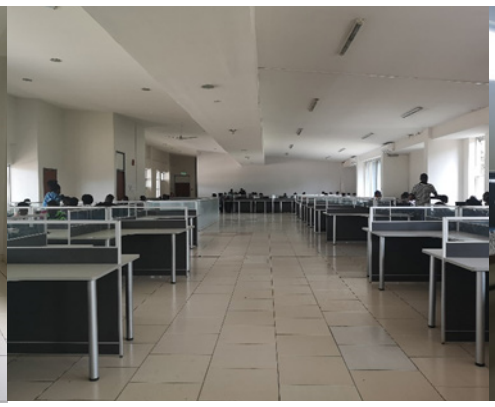


The ACEESD Research (temporary) Office, Nyarugenge campus, the University of Rwanda.

A classroom and A instructors office, Nyarugenge campus, the University of Rwanda.


Welding Workshop, Nyarugenge campus, the University of Rwanda.


University library, Nyarugenge campus, University of Rwanda.


Kigali Cultural Village, located in the University of Rwanda., Nyarugenge campus.


House in Nyamirambo Area, six and a half weeks

Basketary workshop with Nyarugenge womens center

A local shop, a milk bar, and a restaurant in Nyamirambo area

Transportation in the Kigali city in Rwanda; van, motorbike-taxi, and bus

Department stores and supermarket; M Peace Plaza, T-2000 Supermarket, Simba Supermarket, in downtown of the Kigali city (CBD), Rwanda.

The Kimisagara Youth Centre in Kimisagara valley, Nyarugenge District, Kigali City, Rwanda.

Inema arts centre in Kacyiru area, a collection of artists from around the African Continent.

Niyo Arts Gallery in Kacyiru area, a group of local artists' gallery.

Cafe and Coffee class at Question coffee, a social enterprise in Kigali city

Kigali Impact Hub in Kigali city, a social enterprise;
an event space, a co-working, and a consultancy service.

An Office building in Kimurura Area, Westerwelle Start up Haus's location.

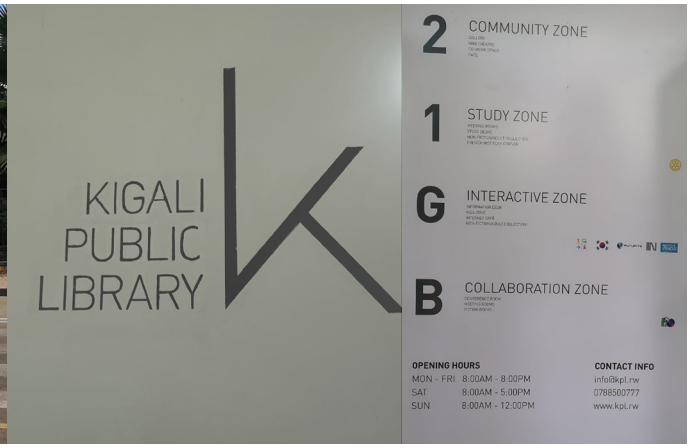
Waka Work in Central Business District (CBD) in Kiyovu area, a co-working space with a gym.

MASS Design Group, An international architectural firm in Kigali City

National Commission of Science and Technology at the Grand Pension Plaza in Central business District (CBD), Kiyovu area; an authority office of research permits for research and data collection in Science and Technology in Rwanda.

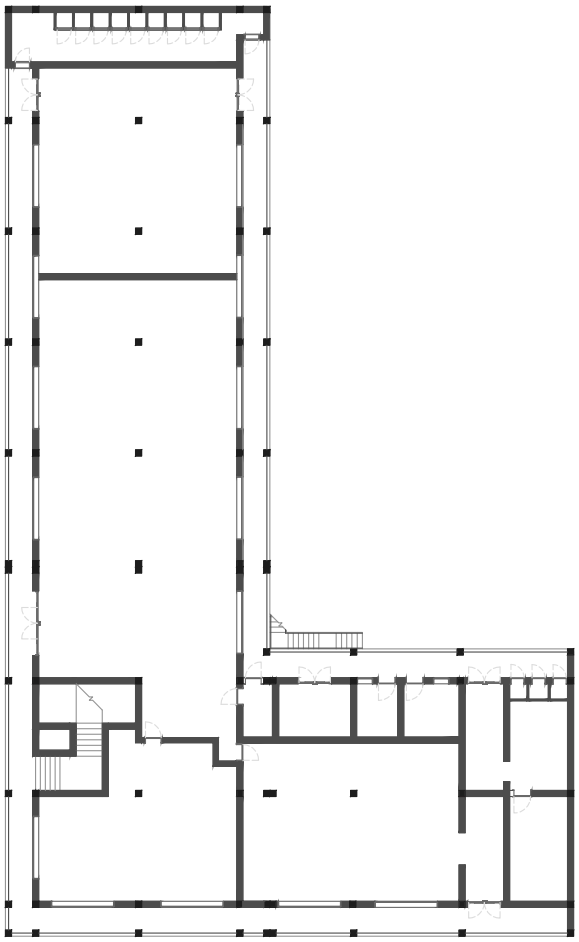
Note: The Grand Pension Plaza building [Image] from The New Times in 2013.

Kigali Public Library, in Kacyiru area



APPENDIX C

CURRENT FLOOR PLANS OF THE EXISTING BUILDINGS



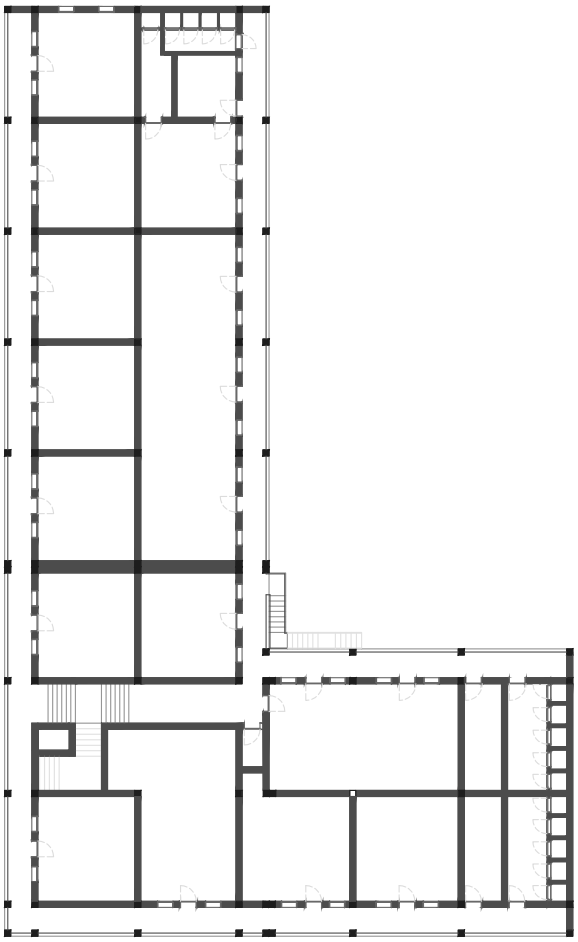
1st Floor Plan

N

0 5 20

2 10

* Not available



N

2nd Floor Plan

0 5 20

2 10

* Not available

PROCESS AND TIME FRAME

Co-Design

Master Thesis

Co-Design

Master Thesis

CTH — UR

Chalmers University of Technology
Dr.Helene Ahlborg
(Project Leader)

University of Rwanda
Dr.Charles Kabiri
(Project Leader)

Research and developing project plan

Week 44 In Gothenburg, Sweden

Preparatory course
and Master Thesis project plan

MPDSD
CTH

Emilio Da Cruz Brandao (Examiner)
Shea Hagy (Supervisor)
Joaquim Tarrasó (Co-supervisor)

Documents and facilities preparing for collaboration

Week 04 - 05 In Gothenburg, Sweden

Theories-1

Background and theoretical study

MPDSD schedule and
Requirements

Co-Design team and ACEESD staff introduction

Shared project consideration

Co-Design plan and schedule

Week 06-07 In Kigali, Rwanda

Prediction-1

Research hypothesis;
'A comprehensive innovation system'

Preparing interview questions

Research permit was assisted by Gasore Geoffrey, an ACE-ESD PhD. researcher, to research and collect data in Rwanda legally

Re-strategies to approach actors and data

Week 11 In Kigali, Rwanda

Prediction-2

Concept;
'The Contradictions'

Presentation to project leaders and business, entrepreneurship and innovation experts

- Pascal Nyiringango
  (Business and Entrepreneurship specialist)
- Dr.Kristina Henricson Briggs
  (Entrepreneurship and innovation specialist)

Presentation to University of Rwanda representative committee.

Week 12 In Kigali, Rwanda
and return to Gothenburg, Sweden

Test-2

Meetings with existing actors and some of future actors

The pandemic of COVID 19, CTH team had to return to Sweden and UR Campus was locked down. The process was paused

Week 13 In Gothenburg, Sweden

Data Collection-2

Mid-term Seminar

Research re-structure and analysis

CO-Design & Master Thesis
Time Frame 2019-2020

Phase 1 - Analysis

Phase 2 - Concept

phase 3 - Design

Week 08 In Kigali, Rwanda

Shared project information and theoritical studies.

Test-1

Primary observation to discover the context and the existing actors of ACE-ESD center

Interview

Week 09 In Kigali, Rwanda

Individual theses development, presentations and shared feedbacks

Data Collection-1

Interim Seminar 1

Challenges of the research and the context

Week 10 In Kigali, Rwanda

Visiting co-working space and innovation hub that exist in Kigali
- Impact Hub Kigali
- Westerwelle Startup Haus
- K-Lab & Fab Lab
- Waka Town

Theories-2

Specific investigation; participant observation and Rwanda history.

Week 14 In Gothenburg, Sweden

Theories-3

Relevant literatures for architectural design

Week 15-17 In Gothenburg, Sweden

Prediction-2

Existing buildings study

Interpretation from the concept to design elements

Week 18-20 In Gothenburg, Sweden

The continuity of the project was discussed.

Test-2

Design development

Interim seminar 2

Week 21-23 In Gothenburg, Sweden

Data Collection-2

Final Seminar

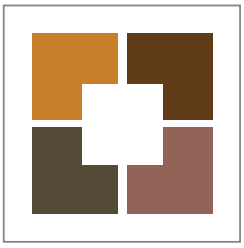
A design proposal, a design strategy, and reflections

TRANSDISCIPLINARITY WITH CONTRADICTIONS

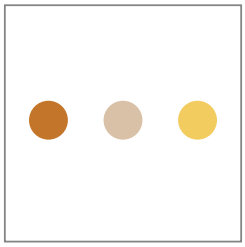
THROUGH SUSTAINABLE ENERGY CO-INNOVATION HUB IN KIGALI

A COMPREHENSIVE INNOVATION SYSTEM

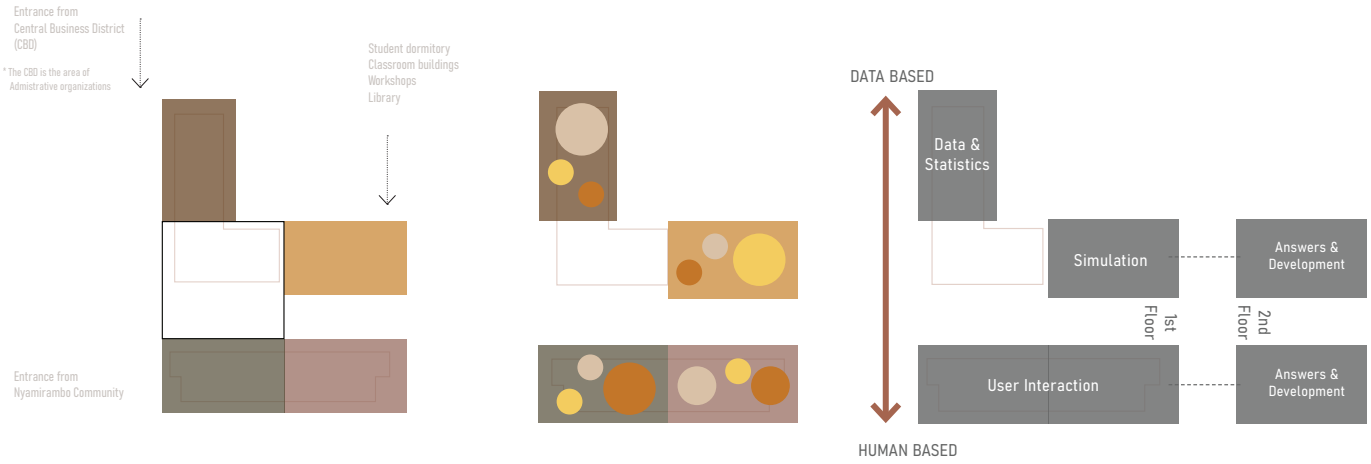
QUADUPLE HELIX



INTERACTIONS



CIRCULAR PROCESS



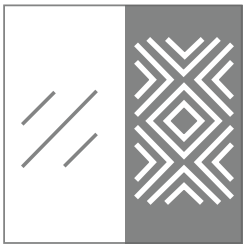
The master thesis began with a curiosity in transdisciplinarity, the collaborative actors, the interactive forms, and the circular process that was introduced through the theoretical research. The combined theories formed the notion of a 'Comprehensive innovation system' within the transdisciplinary approach. When the study of the context started, a design approach with the concept of the contradictions was created. The contradictions led to the notion of 'Duality' and 'Duality' led to the material and immaterial dichotomy as observed in the architectural space and the design elements.

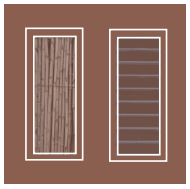
Regarding the architecture of this proposal, theoretical and contextual research were translated into a design proposal with the properties of Duality. This proposal aims to promote the coexistence of different cultural values with seemingly contrasting characteristics. This, in order to promote bidirectional Learning and relations within the educational space.

THE CONTRADICTIONS

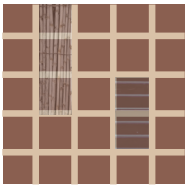
INTERNATIONAL & LOCAL COMMUNITIES

INDUSTRIAL & VERNACULAR

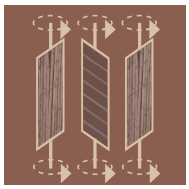




UNITS

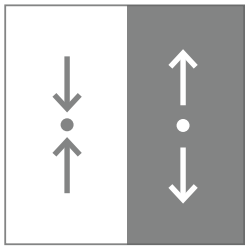


SCAFFOLDING



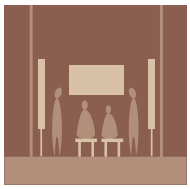
KINETIC

MEETING & BUFFER



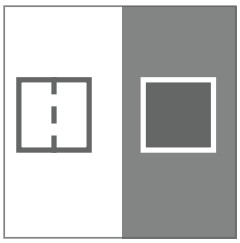
GREEN

FOOD & DRINKS

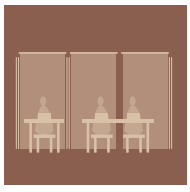


SHOWCASE

SHARED & OWN

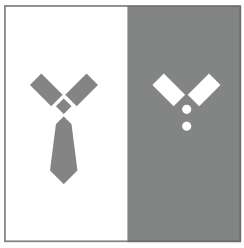


PARTIAL BOUNDARY



FLEXIBLE PARTITIONS

FORMAL & INFORMAL

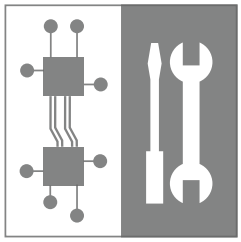


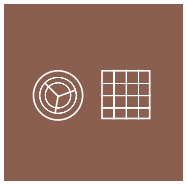
LECTURE

ENTERTAIN

NATURAL RESOURCES

TECNICAL&TRADITIONAL

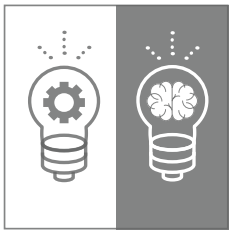


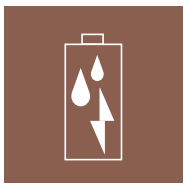


WIND TURBINE & SOLAR CELLS

BIOMASS

USABLE & SENSIBLE





WATER & ENERGY SUPPLY

NATURAL ELEMENTS

CHALMERS
UNIVERSITY OF TECHNOLOGY